
MARKET
SURVEILLANCE
& COMPLIANCE
PANEL
ANNUAL REPORT
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CONTENTS

EXECUTIVE SUMMARY

The Market Surveillance and Compliance Panel (MSCP) Annual Report presents analyses of annual data and information about Singapore's wholesale electricity market. This edition of the report is based on market data and monitoring indices for the period 1 January to 31 December 2022, which were compiled and analysed by the Market Assessment Unit of Energy Market Company as part of its market monitoring and compliance functions. This report is reviewed and approved by the MSCP and provides an assessment of the wholesale electricity market's performance, highlighting key observations on a range of supply, demand, and price indices for 2022, and how they compare to 2021.

Supply Indices

Over the past year, the supply in the National Electricity Market of Singapore (NEMS) experienced the largest decline observed since the market started in 2003. An increase in demand, coupled with the reduction in supply, resulted in lower supply cushion levels in 2022 as compared to 2021, which consequently impacted the wholesale electricity prices in Singapore.

- The average supply decreased 7.06% to 7,374 megawatts (MW) in 2022 from 7,934 MW in 2021. This is in line with an 81.04% increase in the outage level from 1,260 MW per period in 2021 to 2,280.86 MW per period in 2022.
- The resultant average supply cushion[1] weakened to 14.44% in 2022 from 22.19% in 2021.
- The capacity ratios[2] of the Combined Cycle Gas Turbine (CCGT), Open Cycle Gas Turbine (OCGT), and Other Facilities (OT) units decreased 0.50, 0.48, and 10.46 percentage points to annual averages of 64.31%, 2.09%, and 31.40% respectively. On the other hand, the capacity ratio of the Steam Turbine (ST) units increased 7.44 percentage points to an annual average of 9.86% in 2022. New generation types were also added into the market with Energy Storage System (ESS) and Electricity Imports (Import) having a capacity ratio of 3.65% and 37.82% respectively.
- Based on metered energy quantity, the generation sector of the NEMS became more concentrated as the combined market share of the three largest generation companies grew to 52.72% in 2022 as compared to 50.55% in 2021.
- CCGT continued to be the predominant generation type in the NEMS, holding a market share in terms of metered energy quantity of 97.16% in 2022 compared to 98.10% in 2021. The slight decrease in CCGT's market share was picked up by ST, OT and Import whose market share rose to 0.19%, 2.25% and 0.34% respectively as compared to 0.12%, 1.71% and 0% in 2021.

Demand Indices

Following 2021's trend, electricity demand grew by 1.97% in 2022. The increase in demand, pushed up wholesale electricity prices, and represented the highest demand observed since the start of the NEMS in 2003.

- The actual average demand rose 1.97% to 6,300 MW in 2022 from 6,179 MW in 2021. The peak monthly average electricity demand also increased to 6,430 MW, as observed in May 2022, compared to the previous year's peak of 6,333 MW recorded in June 2021.
- The demand spike was mainly caused by the resumption in social and economic activities as Singapore moved from the Transition Phase to Covid-19 Resilience since 26 April 2022, coupled with relatively lower temperatures observed in comparison with 2021.
- The accuracy of real-time load forecast in 2022 improved by a lesser extent than in 2021. The average forecast error shrank a further 0.21 percentage points to 1.5%, the smallest forecast error recorded since the market started.

Price Indices

Higher demand combined with low levels of supply cushion, pushed the annual average Wholesale Electricity Price (WEP) up to $292.41 per megawatt hour (MWh), a record high since the NEMS started in 2003. This was observed in a context of higher fuel oil prices, an increase in the planned and unplanned maintenance of the generation facilities, and tighter supply conditions experienced in the market from 2021.

In the first month of 2022, we saw a continuation of higher WEP, attributable to the surging gas prices and a gas shortage in Singapore due to the disruption of piped natural gas from Indonesia. Subsequently, the WEP prices stabilised for the rest of the year although still being about two times higher as compared to 2021. The daily average Uniform Singapore Energy Price (USEP) registered a high for 2022 at $1,054.62/MWh on 30 January. 2022 recorded the highest yearly average USEP at $291.81/MWh.

- The WEP remained above the $200/MWh level and averaged $292.91/MWh in 2022, 49.74% above 2021's average of $195.62/MWh. This was the highest WEP observed since the NEMS started; the previous high was recorded in 2012 with an average WEP of $223.55/MWh.
- The high WEP in 2022 was primarily driven by a 28.49% rise in the fuel oil price to US$522.73/metric tonne (MT) in 2022 from US$406.81/MT in 2021.
- The total reserve payment rose 111.45% to $169.07 million in 2022 from $79.96 million in 2021, reflecting a 150% increase in the contingency reserve price from $14.43/MWh in 2021 to $36.11/MWh in 2022. This was the highest contingency reserve price recorded since the start of NEMS in 2003.

1 Supply cushion measures supply adequacy, the level of capacity which was offered but not scheduled and could be called up if necessary. Details can be found in the User Guide of this report.

2 Capacity ratio measures the ratio of scheduled output to a Generation Registered Facility's maximum generation capacity. Details can be found in the User Guide of this report.

The Market Surveillance and Compliance Panel (MSCP) is an independent body established under the Singapore Electricity Market Rules (Market Rules). The MSCP's functions and duties under the Market Rules are market monitoring, surveillance, and non-compliance investigation in relation to the National Electricity Market of Singapore (NEMS).

The MSCP monitors and investigates the conduct of market participants, the Market Support Services Licensee, the Power System Operator (PSO) and Energy Market Company (EMC), as well as the structure and performance of, and activities in, the wholesale electricity market that provide indications of the following:

- potential breaches of the Market Rules, the market manuals, or the System Operation Manual (SOM);
- actual or potential design or other flaws and inefficiencies in the Market Rules, market manuals, SOM, and other rules and procedures of EMC or the PSO. This includes an assessment of whether the underlying structure of the wholesale electricity market is consistent with the efficient and fair operation of a competitive market; and
- actual or potential design or other flaws in the overall structure of the wholesale electricity market.

When appropriate, the MSCP may exercise the enforcement powers conferred on it under the Market Rules and recommend remedial actions to mitigate the conduct and inefficiencies referred to above. This includes, but is not limited to, the imposition of financial penalties and the issuance of non-compliance letters, suspension orders, termination orders, and revocation orders. All enforcement actions are administered by EMC at the direction of the MSCP.

Additionally, the MSCP assists the Energy Market Authority (EMA) in fulfilling its obligations regarding competition and abuse of a dominant position under sections 50 and 51 of the Electricity Act 2001.

Structure and Composition of the MSCP

In accordance with the Market Rules, the Chair and members of the MSCP are appointed by the EMC Board for a three-year term of office and may be reappointed. The Panel members are specially selected to ensure that the MSCP as a whole has extensive and relevant experience covering the areas of competitive wholesale electricity market or financial or commodity markets, Singapore laws and/or electricity regulations, competition laws and policies, power system operation, and/or economics.

Since the constitution of the MSCP, the EMC Board has endeavoured to appoint professionals with a range of expertise, such that the combined expertise of MSCP members covers the areas specified and ensures that the MSCP can perform the functions and duties assigned under the authority of the Market Rules, any applicable market manual, constituent documents and any resolution of the EMC Board.

The current composition of the MSCP reflects an appropriate mix of skill sets, experience, and qualifications that are relevant, to assess and safeguard the governance of the market. In exercising its duties, the MSCP is supported by the Market Assessment Unit (MAU).

Professor Walter Woon, Chairman, MSCP

Professor Woon, Senior Counsel, is the chairman of RHTLaw Asia. He is also currently Lee Kong Chian Visiting Professor at the Yong Pung How School of Law, Singapore Management University, an Honorary Fellow of St John's College Cambridge, and an Emeritus Professor at the National University of Singapore, having held the post of David Marshall Professor at the Law Faculty of the National University of Singapore for 12 years until his retirement in 2022.

In addition, Professor Woon has held many prominent appointments in the past, including Attorney-General (2008 to 2010), Solicitor-General (2006 to 2008), Ambassador (1997 to 2006), legal adviser to the President and Council of Presidential Advisers (1995 to 1997) and Nominated Member of Parliament (1992 to 1996).

Professor Woon's main areas of interest are company law, criminal law, and international law. He has published many articles, and written law books and novels.

Professor Woon was appointed a member of the MSCP in 2016 and became the Chairman of the Panel in 2022. During his years as a member of the MSCP, Professor Woon has contributed significantly to the Panel by supporting and clarifying several legal matters related to the application of the Market Rules and the provisions established in the Singapore law.

Mr T P B Menon

Mr Menon is currently a consultant with Wee Swee Teow LLP. Mr Menon was admitted to the Bar on 26 January 1962. He practised with Oehlers & Choa from 1962 to 1988, becoming a senior partner in 1980. Following the merger of Wee Swee Teow & Co with Oehlers & Choa in 1989, Mr Menon took on the role of senior partner at Wee Swee Teow & Co., retiring in 2002 and then acting as a consultant to the firm.

Mr Menon was president of the Law Society from 1980 to 1983 and president of the ASEAN Law Association from 1984 to 1986. He was a member of the Military Court of Appeal from 1980 to 1990 and president of the Strata Titles Boards from 1990 to 1993. He also served as deputy chairman of the Board of Legal Education from 1978 to 2001.

Mr Menon was chairman of the Disciplinary Committee of the Law Society appointed by the Chief Justice from 1991 to 2004 and a member of the Advisory Editorial Board of Halsbury's Laws of Singapore. He has published several articles and delivered papers at international conferences. Mr Menon was awarded a PBM (Pingat Bakti Masyarakat – Public Service Medal) in 1993.

Mr Menon has been a member of the MSCP since 2003, from the commencement of the NEMS, and was the Chairman of the Panel between 2016 and 2021. Mr Menon's extensive legal knowledge and vast experience have enriched and nurtured the decision-making process of the MSCP, making sure that all determinations are fair, efficient, and aligned with the competitive operation of the NEMS, as well as safeguarding the financial integrity of the market.

Er Lee Keh Sai

Er Lee Keh Sai is a registered professional electrical engineer and a chartered engineer. He specialises in electrical power engineering, energy management and power quality solutions and is the Principal of K. S. Lee & Associates, which he established in 1970.

Er Lee was the chairman of the Professional Interviewing Panel for the Professional Engineers Board. He has also served as the Deputy Chairman of the Singapore Polytechnic Board of Governors, Board member of the Institute of Technical Education, and member of the Strata Titles Board. He is also an accredited arbitrator and a member of the Engineering Expert Panel of the Institution of Engineers, Singapore.

Er Lee has regularly published technical papers in the IES Journal on topics such as energy efficiency and electrical protection systems and has been teaching Singapore Certified Energy Manager courses on "Motor Driven Systems" since 2010. He is also a certified trainer for the preparatory course for the registration examination of the Professional Engineer Board.

Er Lee has been one of the longest-serving MSCP members since he was first appointed in 2003. Er Lee's noteworthy expertise has added great value to the Panel by bringing a technical expert angle from his more-than-40 years of solid knowledge of power and energy systems, power plants operation, design, and optimisation. During his years of service, Er Lee's invaluable expertise provided a great understanding of complex technical matters, that supported the governing process and the MSCP's determinations. Er Lee served as a member of the MSCP until the end of 2022 when he decided to retire after 20 years of service.

Mr Philip Chua

Mr Philip Chua is a consultant in the financial industry. Prior to this, he was the senior country executive of American Express Bank Singapore. As the bank's chief executive, he drove local integration of global strategic directions and was also responsible for the bank's governance.

Concurrently, Mr Chua was the head of Global Financial Markets South East Asia, global product head of the Collateralized Trading Program, and regional treasurer for Asia, positions which he assumed progressively after joining the bank. He also served as a council member of the Association of Banks in Singapore and was a lecturer with the Institute of Banking & Finance.

Mr Chua's vast experience in financial markets began with his banking career at Chase Manhattan Bank, where he was Second Vice President and Senior Dealer, Money Market, before joining American Express Bank.

Mr Chua holds a Master of Business Administration from the Kelley School of Business at Indiana University, Bloomington, Indiana, US, and a Bachelor of Science in Business Administration, summa cum laude, from the University of Oregon, Eugene, Oregon, US.

Mr Chua has been a member of the MSCP since 2008. Mr Chua's financial trading and management experience across different instruments and markets have provided the MSCP with a broader perspective of the market dynamics, and market participants' behaviour in response to market conditions, price movements, and market liquidity, ensuring that the MSCP's determinations are consistent with the financial stability of the market.

Professor Euston Quah

Professor Euston Quah is Albert Winsemius Chair Professor of Economics, Professor of Cost-Benefit Analysis and Environment, and Director, Economic Growth Centre at the Nanyang Technological University, Singapore. He is also President of the Economic Society of Singapore, and Editor of the Singapore Economic Review. Professor Quah's extensive research, papers, and articles have been selected for inclusion by the International Library of Critical Writings in Economics in the UK. His textbooks, "Cost-Benefit Analysis", with E.J. Mishan, (6th edition, Routledge UK 2021), and "Principles of Economics", with Gregory Mankiw and Peter Wilson (3rd edition, Cengage Singapore 2021) are used by many universities and governments.

Professor Quah is listed in Google Scholar Profiler since 2020 among the top ten most highly cited university economists in Cost-Benefit Analysis in the world. He has consulted for Gentings International, Price Waterhouse, Canadian International Development Agency, Asian Development Bank, and World Bank, among others. He was formerly Vice Dean of the Faculty of Arts and Social Sciences at the National University of Singapore and headed the economics departments at both Nanyang Technological University and the National University of Singapore. Professor Quah has been, and continues to be, advisor to many government ministries in Singapore. He also serves on the Boards of Competition and Consumer Commission of Singapore, Energy Market Authority, Energy Studies Institute (NUS), Institute of Southeast Asian Studies, among others. He was a recipient of the Public Administration Medal (Silver) in 2020.

Professor Quah has been a member of the MSCP since 2015. His experience undertaking cost-benefit analysis, evaluating government policies, and his extensive knowledge of environmental economics, provide a framework based on economic principles for the analysis of electricity market drivers, market trends, and market player incentives and behaviour. Professor Quah has also been a solid contributor and supporter of the improvements applied to the econometric model for the Uniform Singapore Energy Price outliers.

Dr Stanley Lai

Dr Stanley Lai, Senior Counsel, is the Head of the Allen & Gledhill's Intellectual Property (IP) Practice and Co-Head of the Cybersecurity & Data Protection Practice.

Dr Lai specialises in IP litigation and information technology disputes and is also a commercial/chancery litigator. He maintains a strong advisory practice for IP/data management and cybersecurity, and represents clients in investigations that are undertaken by the Personal Data Protection Commission.

Dr Lai is currently the Chairman of the Intellectual Property Office of Singapore, and the Commissioner of the Government Procurement Adjudication Tribunal and is a member of the Singapore International Arbitration Centre IP Panel and the Singapore Copyright Tribunal. Dr Lai serves as a Senior Mediator in the Singapore Mediation Centre and as a Specialist Mediator in the Singapore International Mediation Centre. He is also an Administrative Panellist at the Asian Domain Name Dispute Resolution Centre.

Dr Lai is the first Singapore-born lawyer to be conferred a Ph.D. in Law from the University of Cambridge. He was awarded the Public Service Medal (Pingat Bakti Masyarakat) at the Singapore National Day Awards 2020 and the Singapore Academy of Law Merit Award in 2022. Dr Lai has published extensively on IP and information technology law, including his book "The Copyright Protection of Computer Software in the United Kingdom".

Dr Lai was appointed a member of the MSCP in 2022. His broad business experience and expertise in Competition Laws provide a further dimension of knowledge to the MSCP, involving the dynamics of different models of market structure, as well as the behaviour and interaction between market players applied to various markets in Singapore.

Decisions of the MSCP

The decisions made by the MSCP lie fundamentally upon the monitoring, evaluations and analyses undertaken by the Market Assessment Unit (MAU), which are regularly reported to the MSCP. Under the Market Rules, the quorum for the transaction of any business at a meeting of the MSCP is a simple majority of the appointed members, and all decisions of the MSCP are made by a majority of the votes cast, with each MSCP member eligible to cast one vote unless there exists a conflict of interest that requires the member(s) to abstain from voting on the given matter.

Where the MSCP concludes that a breach has occurred, a determination recording the facts and circumstances of the breach, and details of any sanctions imposed will be published on the Panel Determinations.

Market Assessment Unit

The MAU manages the market surveillance, compliance, and dispute resolution processes. It advises and supports three external and independent governance bodies: namely the MSCP, the Dispute Resolution Counsellor (DRC), and the Dispute Resolution and Compensation Panel (DRCP).

The MAU assists in the enforcement of compliance with the Market Rules through its surveillance activities, investigations of alleged rule breaches, as well as supporting and advising the independent MSCP on enforcement actions. It monitors the outcomes of the wholesale electricity market and the behaviour of market participants to ensure that the market is functioning efficiently and identifies areas of inefficiency. It provides market training to, and advises, the MSCP on the state of competition and efficiency of the wholesale market, for the MSCP to recommend changes or remedial actions to the EMA to address areas of inefficiency. The MAU also acts as the key point of communication between market players and the MSCP.

The MAU assists the DRC with setting up and maintaining dispute management systems among market participants. It provides market training and operational support to the DRC and the DRCP members on all dispute-related matters.

While the Market Rules provide for employees of the MAU to report to and be administratively managed by EMC, the MAU also reports to and takes direction from the Chairman of the MSCP on all matters related to the market monitoring and investigation duties contained in the Market Rules.

MSCP Annual Reporting

The MSCP Annual Report is developed in accordance with section 4.4.6 of Chapter 3 of the Market Rules. Pursuant to these provisions, the MSCP is required to prepare an annual report on the conduct of its monitoring activities and investigations for submission to EMC and its subsequent provision to the EMA.

The annual report includes a summary of routine reports on the MSCP's monitoring and investigation activities, and a summary of any report regarding the possibility of anti-competitive agreements or the abuse of a dominant position contrary to sections 50 or 51 of the Electricity Act. The report also contains a summary of all complaints or referrals filed and investigations commenced and concluded, a summary of all investigations conducted by the MSCP concerning offer variations after gate closure reported by EMC, and a general assessment by the MSCP of the state of competition and compliance within, and the efficiency of, the wholesale electricity market.

The MSCP Annual Report 2022 covering the period 1 January to 31 December 2022 highlights significant developments regarding the supply, demand, and electricity prices in the NEMS, to inform market participants, potential entrants to the market, the regulatory body, and the industry as a whole about the market conditions observed throughout the year. The MSCP Annual Report also includes a section on the MSCP's market compliance decisions and enforcement actions taken by the MSCP based on the investigation of alleged breaches as part of its monitoring and compliance functions.

This is the 21st report issued and published by the MSCP since 2003 on the wholesale electricity market of the NEMS. All Annual Reports by the MSCP are publicly available on the EMC website, under the MSCP Reports section.


MARKET
MONITORING

Catalogues of Data and Monitoring Indices

The Singapore Electricity Market Rules (Market Rules) provide for the Market Assessment Unit (MAU), under the supervision and direction of the Market Surveillance and Compliance Panel (MSCP), to develop a catalogue of the data it acquires and a catalogue of the monitoring indices to evaluate market performance.

The Catalogue of Data and Catalogue of Monitoring Indices are publicly available on the Energy Market Company (EMC) website. The Catalogues of Data and Monitoring Indices were last reviewed by the MSCP in consultation with the industry and the regulator in 2020 and the new monitoring drivers were adopted and incorporated since the MSCP Annual Report 2020.

On 19 December 2022, the MSCP published a consultation paper to further update the Catalogue of Data. This consultation was undertaken to incorporate new data, including data related to Electricity Imports (Import) and the Power System Operator's (PSO) Directed Supply Scheme (DSS) and Standby Capacity Scheme (SCS). After evaluating the comments, the modified Catalogue of Data was adopted by the MSCP on 1 February 2023. The data collation in accordance with the modified Catalogue of Data will be fully reflected in the MSCP Annual Report 2023. Nevertheless, the monitoring of some of the new data has commenced in 2022 and the assessment of its compliance has been incorporated in the MSCP Annual Report 2022, under the section "State of Compliance within the Wholesale Electricity Market".

Catalogue of Monitoring Indices

The Catalogue of Monitoring Indices adopted by the MSCP includes supply indices, demand indices, and price indices, as listed below:

TABLE 1: CATALOGUE OF MONITORING INDICES

Type of Indices	Description of Indices
Supply Indices	Capacity ratio of a generation registered facility – Ratio of a generation registered facility's (a) scheduled generation output to (b) maximum generation capacity
	Supply cushion – Ratio of (a) the difference between total offered volume and system demand to (b) total offered volume
	Outage frequency
	Market share by: (a) generation type; (b) generation licensee; (c) generation registered facility and corresponding Herfindahl-Hirschman Index (HHI)
	Percentage of time output when there was one pivotal supplier
	Trend of price setting generating units
	Comparison of metered generation quantity with scheduled dispatch quantity by generation registered facility/generation licensee
	Frequency of issuance by the PSO of dispatch instructions deviating from real-time dispatch schedule
	Frequency of offer/bid variations or revisions to standing offers/bids exceeding offer/bid change limits
	Reasons and timings for the change in offer/bid variations exceeding offer/bid change limits
	Frequency of demand response activation and analysis of energy bids
Demand Indices	Comparison of latest available very short-term load forecast with real-time load forecast
	Comparison of real-time load forecast with metered generation quantity
Price Indices	Trend of Uniform Singapore Energy Price (USEP), reserve prices, regulation price and comparison of trends
	Percentage of hours and quantity of load when Wholesale Electricity Price (WEP) falls into a particular price range
	Correlation between WEP and system demand
	Correlation between WEP and fuel price
	Comparison of latest available short-term schedule projected prices with real-time prices

Catalogue of Data

The information contained under the Catalogue of Data is collected by the MAU on a pre-determined frequency from different sources (including EMC, the PSO and market participants) and is broadly categorised as Generation Registered Facility characteristics data, transmission system data, supply data, demand data, pricing data, and other data.

In 2022, MSCP/MAU acquired new monitoring functions arising from the new dynamics as part of the market evolution observed in the year. One of the developments in the National Electricity Market of Singapore (NEMS) was the introduction of pre-emptive measures by the Energy Market Authority (EMA) to strengthen the Singapore Wholesale Electricity Market, namely the DSS and SCS. In another development to diversify Singapore's energy sources, the EMA also worked with various partners on trials to import electricity from neighbouring ASEAN countries on a commercial basis.

Indicators of Market Performance

The MAU submits regular market performance monitoring updates to the MSCP. These updates include observations of several market performance indicators which are broadly classified into supply, demand, price, as well as energy and ancillary services indices.

BOX 1. MARKET ASSESSMENT UNIT'S NEW MONITORING FUNCTIONS

The Market Assessment Unit's (MAU) monitoring functions were enhanced with the introduction of the Directed Supply Scheme (DSS), Standby Capacity Scheme (SCS) and Electricity Imports (Import) trial implemented by the Energy Market Authority (EMA).

In the last quarter of 2021, wholesale electricity prices soared due to global fuel shortage and unplanned curtailment of piped natural gas supply from Indonesia. This continued in January 2022, and the situation was exacerbated by the conflict between Russia and Ukraine that led to a surge in the prices of oil and gas. In this context, the EMA introduced the Standby Liquefied Natural Gas Facility (SLF) to enable generators to access the fuel via gas allocations under the DSS and SCS schemes, that were introduced from 21 December 2021 and 4 March 2022, respectively.

Directed Supply Scheme[3]

Under the DSS, the Power System Operator (PSO) pre-emptively directs generation companies to generate using their own fuel (either diesel or gas), or gas from the SLF, in the event of a projected supply shortfall in the Singapore Wholesale Electricity Market (SWEM).

New modifications to the Market Rules were made to give effect to the DSS. This included clarity on the scope of the directions issued by the PSO as well as the recovery of compensation/refund arising from the scheme.

As part of the DSS, generation companies are requested to submit offer variations to reflect the loading specified by the PSO. Offer variations submitted after gate closure are reported to the MSCP for investigation. During 2022, the MSCP/MAU has worked closely with the EMA on the treatment of these offer variations made after gate closure.

Standby Capacity Scheme[4]

The SCS is a measure to further enhance the energy security and stability of Singapore's power system and market. Under the SCS, the EMA further procures standby generation capacity from participating generation licensees. When needed, the participating licensees will be called upon to increase generation supply in the SWEM to enhance power system security, reliability and stability, and mitigate price volatility.

Similar to the DSS, generation companies are requested, under the SCS, to submit offer variations within gate closure to reflect the loading specified by the EMA. These offer variations, which are submitted after gate closure, are reported to the MSCP for investigation. The MSCP/MAU works closely with the EMA on the treatment of these offer variations made after gate closure.

3 Energy Market Authority final determination paper, 4 March 2022, "Modifications to Electricity Market Rules in Relation to Measures to Secure and Stabilise the Power System and Market".
4 Ibid.

Electricity Imports[5]

The Lao PDR-Thailand-Malaysia-Singapore Power Integration Project (LTMS-PIP) commenced on 23 June 2022. Under the project, Singapore is importing up to 100 megawatts (MW) of renewable energy from existing hydropower plants in Lao PDR for a two-year period, through the interconnector with Malaysia. This cross-border electricity trading mechanism has required the introduction of a new market participant class: the importer licensee.

In terms of requirements, electricity importers are required to do the following:

1. *Participation in the Singapore Wholesale Electricity Market (SWEM).* The importer is required to register with Energy Market Company (EMC) as a market participant (MP) and be subject to the Market Rules The importer must provide offers into the energy market and compete to secure dispatch into the Singapore network for each half-hourly period.

2. *Automatic Financial Penalty Scheme (AFPS).* Under the Market Rules, the AFPS will also apply. Penalties will be imposed if actual power quantity deviates from each half hourly real time dispatch schedule by more than 10 MW. The AFPS is not applicable to trial imports via the existing Singapore-Malaysia Interconnector, as the Pay-As-Scheduled Settlement is used for these trial imports.

3. *Market share cap for existing generation companies.* The EMA has established a cap of 25% on the generation capacity market share (25% market share cap) to prevent the structural increase in electricity generation market concentration.

4. *Eligibility to provide reserve and regulation.* All generating units that are greater than 10 MW are required to provide reserves and regulation.

5. *Settlement. By default, the settlement approach for imported electricity is "Pay-As-Metered".* The importer is expected to deliver the scheduled quantity in each half-hourly dispatch period and will be paid based on the metered quantity.

New modifications to the Market Rules were required to ensure that the Electricity Imports are made in an orderly manner, as this has had an impact on the monitoring functions of MAU to closely monitor the obligations imposed on the import facilities and the interconnectors.

To ensure there is no hoarding of interconnector capacity, the importer is obligated to ensure that its energy schedule for every hour is no less than the minimum scheduled quantity set by the EMA, save for prescribed circumstances, namely whether the Import Registered Facility (IRF) or any part of the interties is on outage, and if it had been ordered, directed or instructed by the PSO to be scheduled at a different level. Any breach of the foregoing requirement will be reported to the MSCP for investigation. The MSCP, with the assistance of the MAU, conducts compliance checks on this new market rule. EMC supports MAU on the monitoring by providing data on the scheduled quantity of each import facility in each hour, as well as the connection status of the interties to check if they qualify for the exemption under the Market Rules. MAU also conducts its own separate compliance check on whether the exemption would apply when the facility or any part of the interties is on maintenance, and if there were any corresponding instructions issued by the PSO.

The MSCP also assesses if the offer variation after gate closure submitted by the IRF is in breach of the Market Rules. The MAU supports the MSCP in arriving at its determination by conducting compliance checks on whether any of the exemptions apply for the offer variation, namely checks on whether there was a forced outage or failure to synchronise incidents and if there was any transmission constraint within the interconnected system.

The above monitoring process was considered as part of the modifications to the Catalogue of Data conducted on 19 December 2022 and it will be included in the MSCP Annual Report 2023.

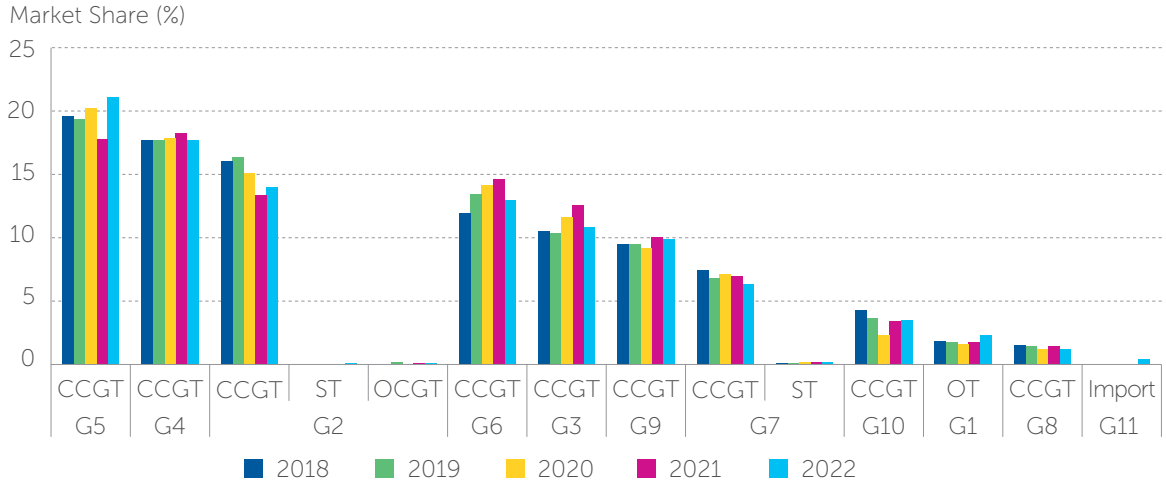
5 Energy Market Authority, 1 July 2022, "Guide to Electricity Imports".

Chart 1 shows the market share by generation type under each generation company in the NEMS measured by the metered energy quantity for the last five years. The generation companies are arranged in descending order according to their market share based on metered energy quantity in 2022.

The market is largely dominated by the Combined Cycle Gas Turbine (CCGT) units, which recorded a market share of 97.16% in 2022, while Other Facilities (OT) units under G1, Electricity Imports (Import) under G11, Steam Turbine (ST) units under G2 and G7, and Open Cycle Gas Turbine (OCGT) units under G2, accounted for 2.25%, 0.34%, 0.19% and 0.06% of the market respectively. The market shares across the generation mix remained largely similar over the last five years, with strong dependency on the more efficient CCGT units of above 97% since 2018. However, this year saw a slight reduction in the CCGT type which could be due to the entry of a new generation type, Import, under G11.

The Import under G11 commenced providing supply into the system from 13 June 2022 and constituted 0.34% of total metered energy quantity in the year. The OCGT and ST units under G2 and G7 ran intermittently over the last five years and therefore are not significantly reflected in Chart 1.

CHART 1: MARKET SHARE BASED ON METERED ENERGY QUANTITY BY GENERATION COMPANY AND GENERATION TYPE



OT = other facilities, i.e., incineration plants that convert energy from incinerated refuse

Table 2 shows the yearly average market share of all generation companies in terms of metered energy quantity. The top three generation companies with the largest market share by metered energy quantity in 2022 are G5, G4, and G2. While G5 and G4 are still in the top two positions, G4 lost its first place to G5, and G2 replaced G6 in third place when compared to 2021. The combined market share of the top three generation companies increased to 52.84% in 2022 from 50.55% in 2021, and declined 0.35 percentage points over the past five years.

The market share based on metered energy quantity by generation companies in 2022 could have been impacted by the PSO directing market participants (MP) to generate using gas from the Standby LNG Facility under the DSS. Therefore, changes in the market shares of MPs this year could be partly influenced by the PSO's directions.

TABLE 2: MARKET SHARE BASED ON METERED ENERGY QUANTITY BY GENERATION COMPANY (%)

Year	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11
2018	1.77	16.03	10.45	17.64	19.52	11.91	7.48	1.51	9.47	4.21	–
2019	1.74	16.36	10.35	17.66	19.29	13.36	6.81	1.38	9.41	3.64	–
2020	1.57	15.04	11.54	17.81	20.18	14.12	7.17	1.20	9.13	2.23	–
2021	1.71	13.36	12.54	18.24	17.75	14.55	7.02	1.37	10.03	3.41	–
2022	2.25	14.10	10.77	17.68	21.06	12.91	6.42	1.20	9.86	3.42	0.34

Note: The percentages in this table may not add up to 100% due to rounding.

CHART 2: MARKET SHARE BASED ON MAXIMUM CAPACITY BY GENERATION COMPANY AND GENERATION TYPE

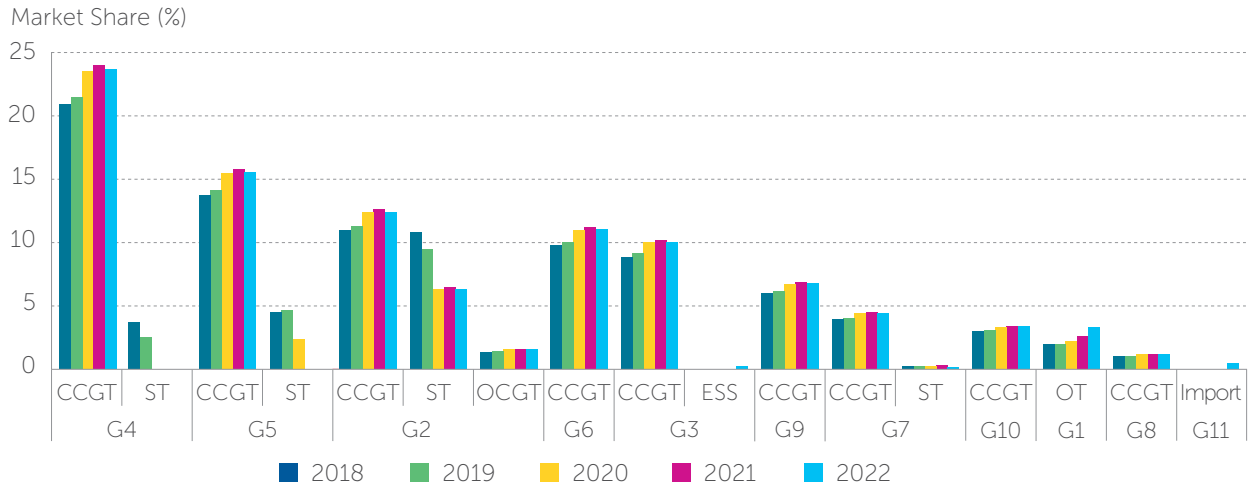


Chart 2 shows the market share based on maximum capacity by generation company. The generation companies are arranged in descending order according to their CCGT market share in 2022.

The annual average market share of all generation companies by CCGT, ST and OCGT generation types based on maximum capacity declined in 2022 due to the registration of two new generation types – the Import and the Energy Storage System[6] (ESS) – which has diluted the market share of the rest. The market shares of Import and ESS in 2022 were 0.46% and 0.21% respectively. Correspondingly, the market shares of CCGT, ST and OCGT fell by 1.29 percentage points, 0.09 percentage point, and 0.02 percentage point respectively when compared to 2021.

6 Based on actual capacities of the ESS facilities.

TABLE 3: MARKET SHARE BASED ON MAXIMUM CAPACITY BY GENERATION COMPANY (%)

Year	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11
2018	1.91	23.02	8.83	24.51	18.16	9.73	3.97	0.99	5.94	2.94	–
2019	1.96	22.08	9.08	23.94	18.69	10.01	4.08	1.02	6.11	3.02	–
2020	2.15	20.10	9.95	23.49	17.75	10.96	4.47	1.12	6.69	3.31	–
2021	2.57	20.50	10.14	23.95	15.75	11.18	4.56	1.14	6.83	3.38	–
2022	3.31	20.20	10.20	23.61	15.52	11.02	4.50	1.12	6.73	3.33	0.46

Note: The percentages in this table may not add up to 100% due to rounding.

Table 3 consolidates the yearly average market share of all generation companies in terms of maximum capacity. There was no change in the position of the three largest generation companies based on their yearly average market share. In terms of market share by maximum capacity, the combined market share of the three largest generation companies continued to shrink as it fell 0.87 percentage points to 59.33% in 2022 when compared to 2021. This was largely due to the entry of the new market participant, G11, which diluted the individual market shares observed in previous years.

Of the generation companies, G1 recorded the largest increase of 0.74 percentage point in market share to 3.31% in 2022 from 2.57% in 2021. On the other hand, G4 recorded the largest decrease of 0.34 percentage points in market share to 23.61% in 2022 from 23.95% in 2021.

On the other hand, the market share of OT increased by 0.74 percentage point when compared to 2021.

BOX 2. EMA MEASURES TO SECURE AND STABILISE THE POWER SYSTEM AND MARKET

In response to the global energy crunch and disruptions to piped natural gas (PNG) supply, the Energy Market Authority (EMA) has, since October 2021, introduced pre-emptive measures to secure Singapore's fuel and electricity supply. These include directing generation companies (gencos) to procure sufficient fuel under section 27(1) of the Electricity Act, as well as establishing a Standby Liquefied Natural Gas Facility (SLF) which gencos can draw upon if their PNG supplies are affected. In the event of a projected supply shortfall in the Singapore Wholesale Electricity Market (SWEM) to meet demand, the EMA could pre-emptively direct generation companies to generate using gas from the SLF, if needed, in accordance with the System Operation Manual under the Directed Supply Scheme (DSS).

In addition to the DSS, the EMA also introduced the Standby Capacity Scheme (SCS) to further enhance energy security and stability of Singapore's electricity system and market, as well as to curb the vicious cycle of reduced electricity supply and retail contracts affecting all market participants and consumers. Under the SCS, the EMA will procure standby generation capacity from participating generation licensees. The participating licensees will be called upon to increase generation supply in the SWEM, if needed, to enhance power system security, reliability and stability, and mitigate the Uniform Singapore Energy Price (USEP) volatility. These licensees may either tap on their own fuel, or standby gas to generate the required capacity.

BOX 3. ENERGY STORAGE SYSTEM

In November 2022, an Energy Storage System (ESS) was installed in Singapore and registered as new facilities in the National Electricity Market of Singapore (NEMS) to provide 200 megawatts (MW). The fast-response nature of ESS also allows it to actively manage unbalances in electricity supply and demand and perform regulation services to address second-to-second fluctuations in the power grid, which can mitigate the impact of solar intermittency.

In view of the price volatility experienced by Singapore in Q4 2021, the ESS can also be used to store energy to provide reserves to the power grid when needed, freeing up power generation plants to generate more electricity to meet demand.

TABLE 4: HERFINDAHL-HIRSCHMAN INDEX

Year	Minimum	Maximum	Average	Maximum Share (%)
2018	1,342	1,413	1,372	19.52
2019	1,349	1,467	1,400	19.29
2020	1,350	1,534	1,441	20.18
2021	1,322	1,433	1,366	18.24
2022	1,326	1,512	1,407	21.06

The Herfindahl-Hirschman Index (HHI) is a globally-used measurement of market concentration in the electricity markets. A higher HHI indicates a decrease in the number of generation companies in the market and/or a larger difference in proportion of market share among the generation companies.

The HHI is the sum of squares of the market share of each firm in a market based on the generation companies' metered energy quantity and expressed as decimals – multiplied by 10,000.

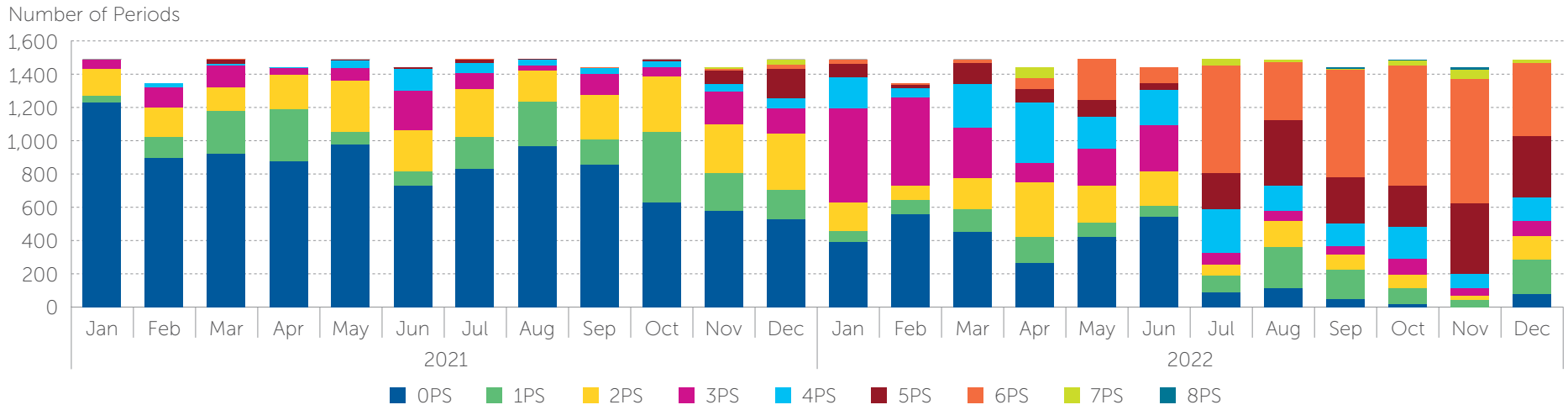
In Table 4, the HHI calculates the market share of generation companies measured by the metered energy quantity of the annual electricity generation.

The HHI classifies the electricity market into three categories: in "unconcentrated markets" where the index is below 1,000, in "moderately concentrated markets" where the index is between 1,000 and 1,800, and in "highly concentrated markets" where the index is above 1,800. The classification is adopted from the United States Department of Justice and the Federal Trade Commission under the Horizontal Merger Guidelines in 1992.

The monthly average HHI increased to 1,407 in 2022 from 1,366 in 2021, in line with the increase in the maximum market share held by the generation company with the highest percentage of metered energy quantity to 21.06% in 2022 from 18.24% in 2021, as observed in Table 2. The higher maximum market share held by one generation company means a corresponding decline in the proportion of metered energy quantity held by the rest of the generation companies.

Nevertheless, the NEMS remained moderately concentrated as there was no significant change in the proportion of metered generation quantity in the market in 2022. Over the last five years, the monthly HHI of the NEMS hovered between 1,300 and 1,600, which lies in the "moderately concentrated markets" range of 1,000 to 1,800.

CHART 3: FREQUENCY OF GENERATION COMPANIES AS PIVOTAL SUPPLIERS PER PERIOD



The pivotal supplier test is an indicator of structural market power in the NEMS. A pivotal supplier (PS) is present when the total system demand for a particular period cannot be met without including the supply capacity of any one MP.

Chart 3 above displays the number of periods where pivotal suppliers are present in the market for each month in 2021 and 2022. Throughout the review period from 2021 to 2022, the maximum number of pivotal suppliers recorded per period is eight.

The total number of periods with no PS decreased 70.25% to 2,982 periods in 2022 from 10,025 periods in 2021, while the number of periods with five or more pivotal suppliers increased more than 16 times to 6,652 periods in 2022 from 408 periods in 2021. This could be attributed to the tighter yearly average supply in 2022, as the supply cushion fell to a historic low due to the contraction of supply despite higher forecasted demand.

Given the record low supply cushion in 2022, it is reasonable for generation companies, with relatively smaller capacities, to become pivotal suppliers. As additional generation companies were identified as pivotal suppliers, these market participants may have gained unilateral market power in 2022.

TABLE 5: CAPACITY RATIO BY GENERATION TYPE (%)

Year	CCGT	ST	OT	OCGT	Import	ESS
2021	64.80	2.42	41.86	2.57	–	–
2022	64.31	9.86	31.40	2.09	37.82	3.65
YOY Change	-0.49	7.44	-10.46	-0.48	–	–

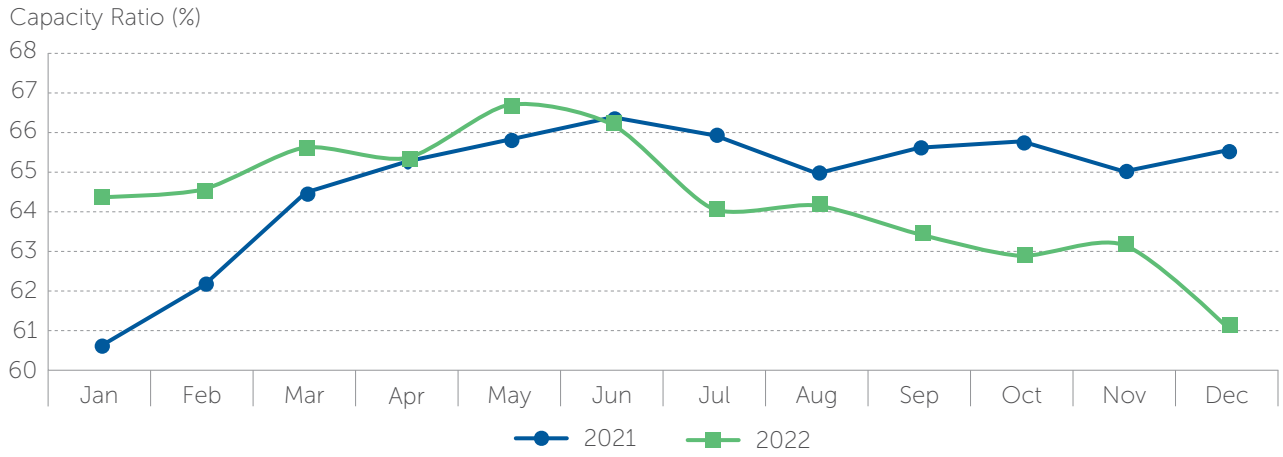
The capacity ratio represents the utilisation level of a generation type. Table 5 compares the yearly average capacity ratio of the four generation types in 2021 and 2022.

In 2022, the capacity ratios were lower for the CCGT, OT and OCGT generation types compared to 2021, which might be attributed to the higher planned maintenance levels of CCGT, OT and OCGT units. Despite being the more expensive generation capacity type in the market and having a higher planned maintenance level in 2022, the utilisation rate of the ST unit increased, as the market experienced an increase in the number of directions issued by the EMA to the ST units as part of the pre-emptive measures introduced by the Authority to secure fuel and electricity supply in March 2022.[7] The capacity ratio for ESS was relatively low as ESS is intended to provide reserves to the power grid when needed, freeing up baseload generation plants to generate more electricity to meet demand.

The Lao People's Democratic Republic-Thailand-Malaysia-Singapore Power Integration Project (LTMS-PIP) is the first electricity import trial, and a moderate level of capacity ratio for Import is expected during the initial two years of trial period, as the generation company conducts feasibility tests and gains experience from the trial.

Overall, the NEMS continued to rely on the CCGT units to meet system demand. The CCGT units continued to hold the largest capacity ratio by generation type, as the most efficient generation type in the NEMS.

CHART 4: COMPARISON OF CAPACITY RATIOS OF CCGT UNITS



A monthly comparison of the capacity ratio of CCGT units in 2021 and 2022 is shown in Chart 4. Overall, the yearly average capacity ratio for CCGT units reduced 0.49 percentage points to 64.31% in 2022 from 64.80% in 2021.

In 2022, the monthly average capacity ratio of CCGT units was lower than in 2021. Since June 2022, the lower capacity ratios observed could be attributed to the higher level of planned maintenance for CCGT's compared to 2021.

7 Energy Market Authority final determination paper, 4 March 2022, "Modifications to electricity market rules in relation to measures to secure and stabilise the power system and market".

TABLE 6: AVERAGE OUTAGES BY GENERATION TYPE (MW)

Year	Planned Outages							Forced Outages							Total Outages	YOY Change (%)
	CCGT	ST	OT	OCGT	Import	Sum	%	CCGT	ST	OT	OCGT	Import	Sum	%		
2018	874.63	241.96	13.82	32.40	–	1,162.82	98.81	13.53	0.41	0.02	0.00	–	13.96	1.19	1,176.78	3.76
2019	961.64	299.29	5.82	14.43	–	1,281.18	94.57	73.51	0.02	0.06	0.00	–	73.59	5.43	1,354.77	15.13
2020	965.25	91.79	25.23	33.87	–	1,116.15	92.57	89.27	0.02	0.24	0.00	–	89.53	7.43	1,205.67	-11.01
2021	1,027.38	106.99	26.76	5.39	–	1,166.53	92.59	84.08	7.62	1.19	0.48	–	93.37	7.41	1,259.90	4.50
2022	1,751.34	317.90	98.03	12.79	10.57	2,190.63	96.04	88.85	0.32	0.89	0.01	0.16	90.23	3.96	2,280.86	81.04

Note: Outage volume of ESS is excluded as ESS outage data for 2022 is unavailable.

Table 6 provides an overview of the periodic outage volume by generation type for the last five years. The yearly total outages rose every year from 2018 to 2022, except 2020, which was the only year that recorded an annual decline.

The average planned outage volume in 2022 recorded the highest over the past five years.

The average planned outage volume increased across the board for CCGT, ST, OT, and OCGT units in 2022 compared to 2021, with the CCGT units recording the largest increase in planned outage volume from 1,027.38 megawatts (MW) to 1,751.34 MW. The increase in CCGT planned maintenance could be attributed to several CCGT units nearing the end of their economic lifetime.

In 2022, the volume of annual average forced outages per period of 90.23 MW was the second highest recorded over the past five years

CHART 5: PLANNED OUTAGES VS USEP

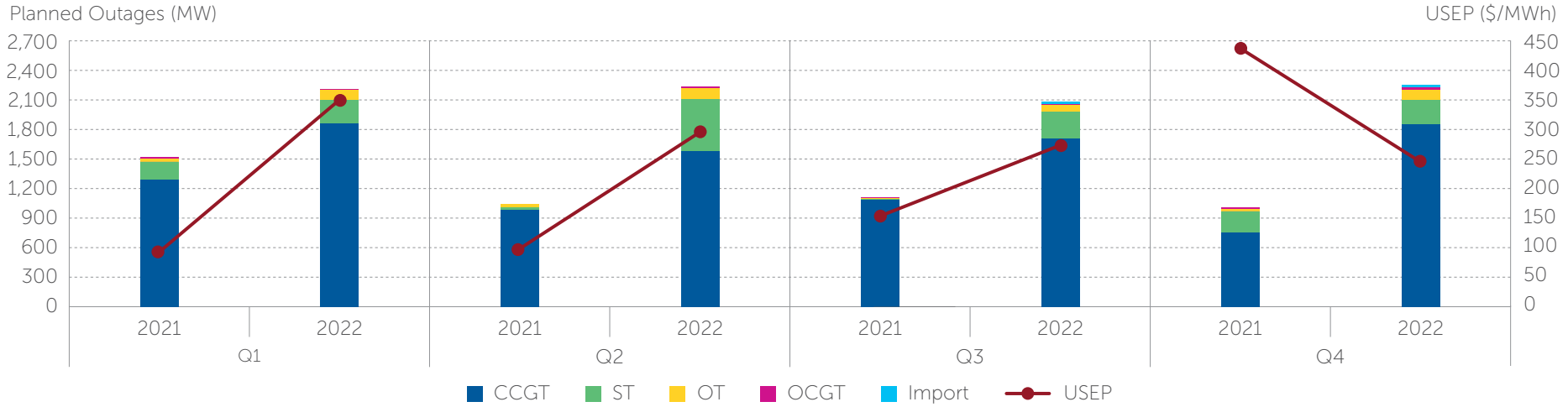


Chart 5 compares the quarterly average planned outages against the quarterly average USEP in 2021 and 2022. The USEP moved in tandem with the planned outage volumes in Q1, Q2, and Q3, as a higher level of planned outages usually coincides with a higher USEP due to the contraction in supply.

In Q4, the USEP fell despite higher planned outage volumes. This could be due to the extreme price volatility experienced in Q4 2021 due to the disruption of gas supply to Singapore. Therefore, the USEP in Q4 2021 could not be explained by the usual market conditions (e.g. supply and demand).

CHART 6: AVAILABLE GENERATION CAPACITY

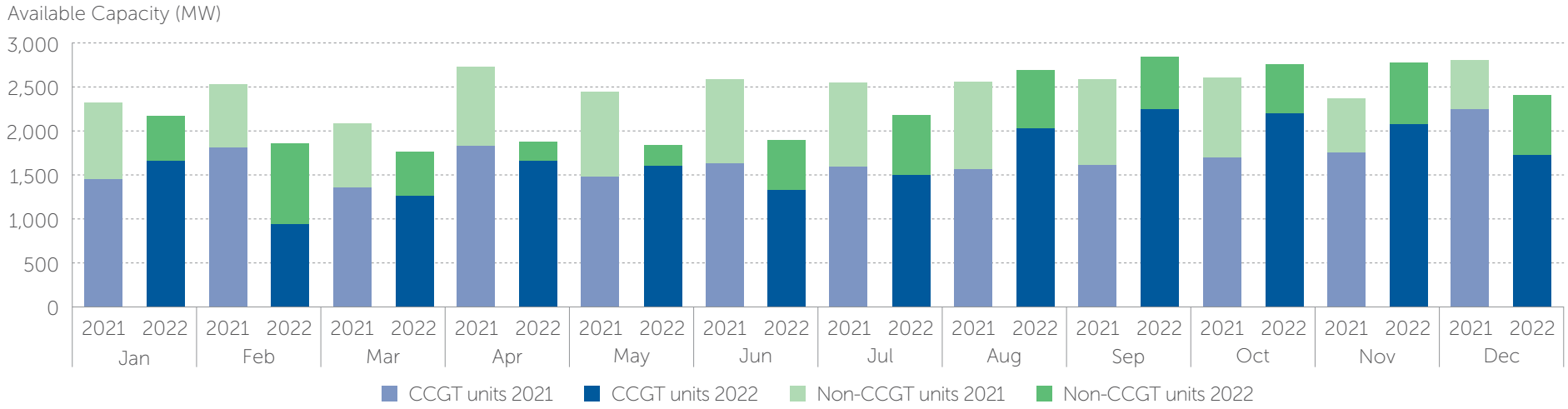


Chart 6 shows the available generation capacity on a monthly basis in 2021 and 2022. The generation capacity refers to capacity that is not offered to the market despite not on planned/unplanned maintenance.

For the first half of 2022, the total available generation capacity averaged 22.91% lower than the first half of 2021, as there were more supply offers from the non-CCGT generation types (e.g. ST, OT, OCGT). Generally, the non-CCGT generation types have high available generation capacity as they are not baseload providers and are only likely to offer into the system under certain market conditions.

The decline in generation capacity of the non-CCGT generation types in 2022 could be attributed to the PSO directions issued under the DSS since the start of the year. These non-CCGT generation types could have been directed by the PSO to offer into the system more frequently, including offer capacity above their minimum stable load.

For the second half of 2022, the total available generation capacity increased and reached monthly levels comparable to 2021. The increase was largely led by the surge in the available CCGT capacity, in particular, from August to November 2022.

For the same period, more frequent and higher levels of curtailment of piped natural gas from Indonesia to Singapore were observed. Given that CCGT mainly operates on natural gas, such gas curtailment occurrences may have resulted in a shortage of main fuel for the CCGT units and contributed to the increased available generation capacity observed in the second half of 2022.

CHART 7: RELATIONSHIP BETWEEN SUPPLY CUSHION AND USEP

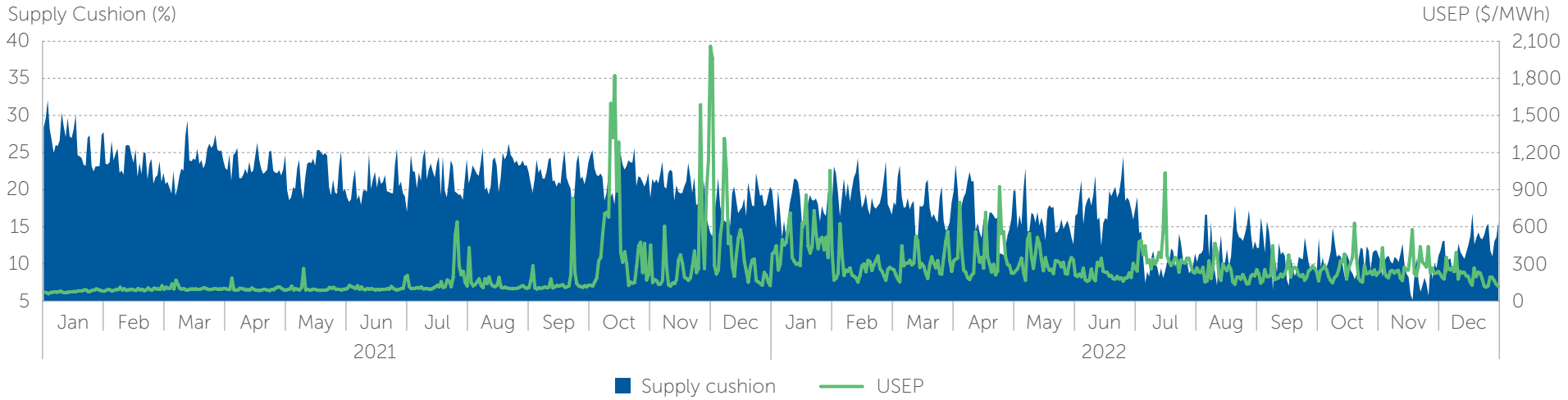


Chart 7 illustrates the relationship between the daily average USEP and the daily average supply cushion for 2021 and 2022. The supply cushion measures the level of spare capacity available after dispatch. Generally, the USEP and the supply cushion are inversely correlated. A lower supply cushion usually results in a higher USEP, due to the tight supply condition when more expensive supply is dispatched to meet the demand.

This is reflected in Chart 7 as the yearly average supply cushion in 2022 tightened 7.73 percentage points to 14.46% – the lowest annual average supply cushion since market start. Correspondingly, the yearly average USEP increased 48.63% from $196.33/MWh in 2021 to $291.81/MWh in 2022 – the highest annual USEP since the market started.

The record low supply cushion was mainly driven by the low supply due to high planned maintenance as shown in Table 6. Additionally, the market observed a surge in the available CCGT capacity in excess of offer capacity especially in the second half of 2022, which might have further exacerbated the tight supply situation.

Compared to Q4 2021, the USEP volatility decreased in 2022 despite the lower supply cushions observed. According to the EMA, the high USEP volatility in Q4 2021 was attributed to generation companies' risk aversion behaviour amidst the surge in fuel prices.[8] Since then, the EMA has implemented several measures to strengthen Singapore's wholesale electricity market, which include the DSS and the SCS.

8 Energy Market Authority, 25 October 2022, "Opening keynote address by Minister Gan Kim Yong at the Singapore International Energy Week (SIEW) summit".

CHART 8: RELATIONSHIP BETWEEN SUPPLY CUSHION AND USEP IN 2022

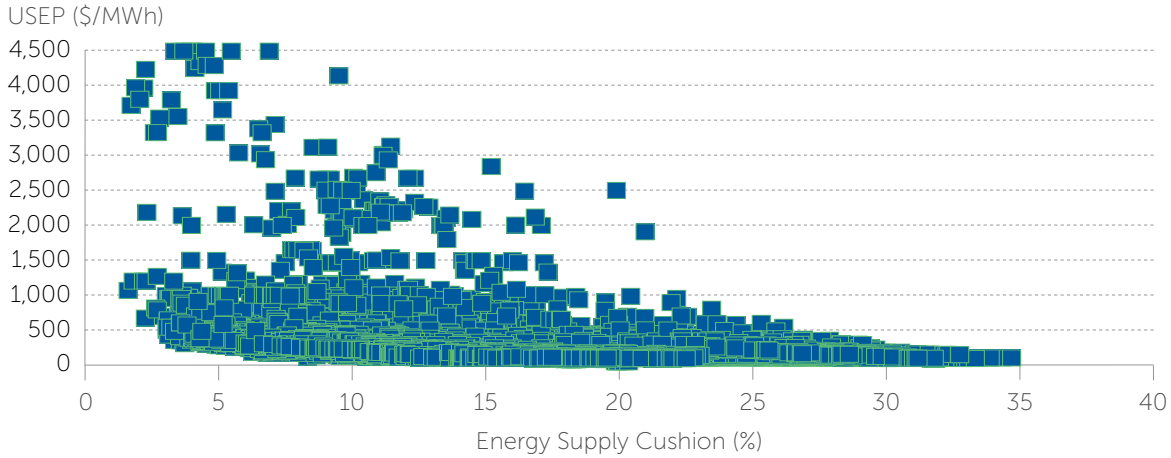


Chart 8 shows the relationship between the USEP and the supply cushion in 2022 across all dispatch periods.

The periodic USEP exceeded $400/MWh on 2,871 instances in 2022 compared to 1,139 in 2021. This is in line with the historical trend, which has shown that price spikes occur when the supply cushion falls below the 15% level. In 2022, 87.08% of the 2,871 instances where the periodic USEP exceeded $400/MWh were observed when the supply cushion was below 15% level.

TABLE 7: RELATIONSHIP BETWEEN SUPPLY CUSHION (%) AND USEP ($/MWH)

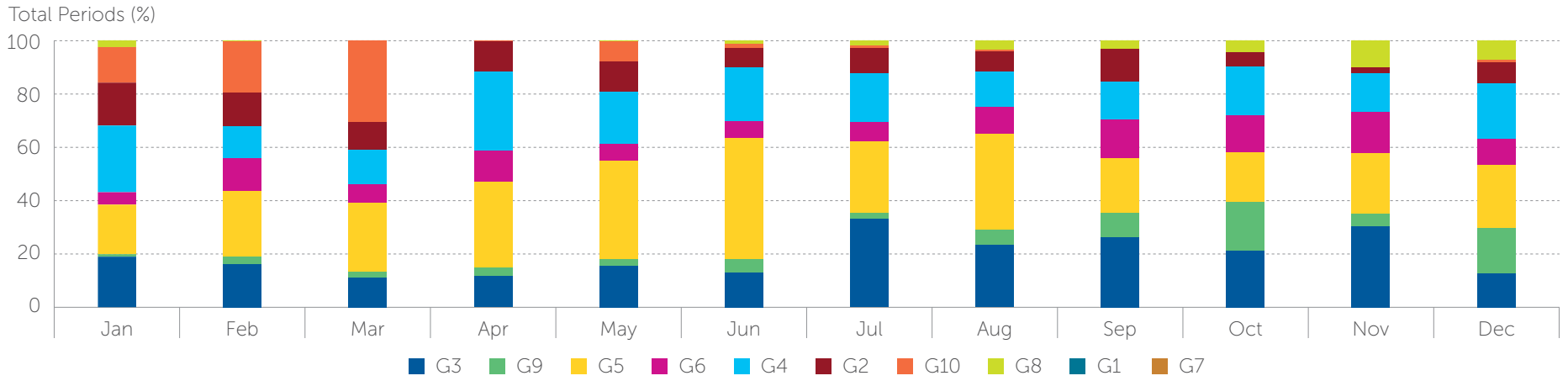
Year	Supply Cushion < 15%			Supply Cushion ≥ 15%		
	Number of Periods	Average USEP	Max USEP	Number of Periods	Average USEP	Max USEP
2018	216	453.73	1,354.60	17,304	106.01	924.33
2019	222	306.18	1,354.86	17,298	95.61	1,187.31
2020	848	167.28	1,254.04	16,720	65.07	570.72
2021	1,713	623.76	4,499.09	15,807	150.01	3,007.35
2022	10,703	348.60	4,500.00	6,817	202.64	2,847.83

Table 7 summarises the yearly average USEP movements with a supply cushion of more and less than the 15% level over the past five years. In line with Chart 7, the number of periods for which the supply cushion was below the 15% level rose significantly from 2021 to 2022.

In 2022, 61.09% of the periodic supply cushion fell below the 15% level, compared to 9.78% in 2021. For instances where the periodic supply cushion fell below the 15% level, the average periodic USEP was $348.60/MWh and $623.76/MWh in 2022 and 2021 respectively. This indicates that the market cleared at relatively lower price tranches under tighter supply conditions in 2022 compared to 2021.

The tighter supply cushion could be attributed to the higher level of planned maintenance, as shown in Table 6. The average periodic USEP was relatively low despite the record low supply cushion, given the EMA's measures to stabilise the market as explained in Chart 7.

CHART 9: TREND OF PRICE SETTING GENERATION COMPANIES



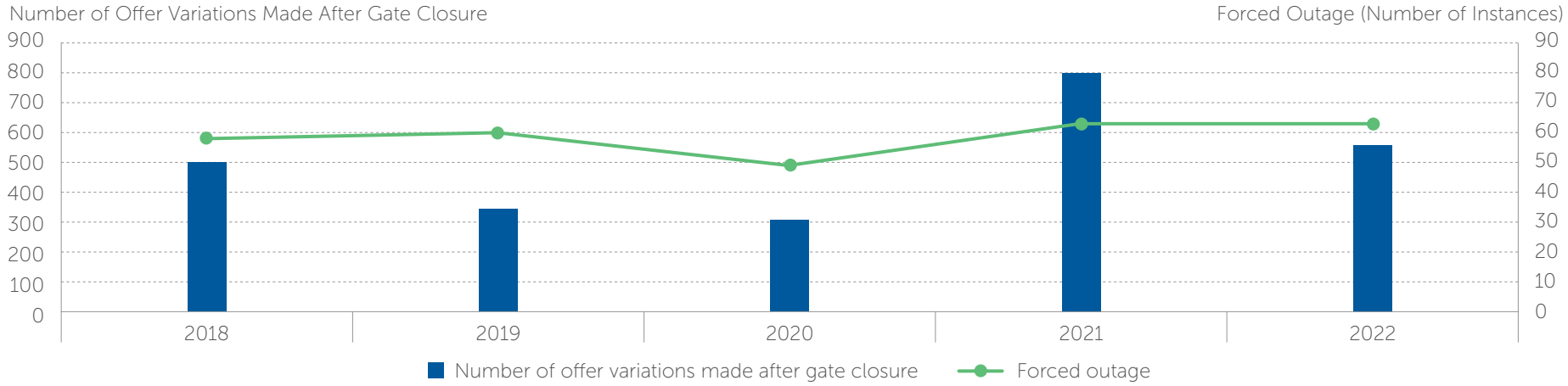
Price setter refers to the generation company which provides the block price quantity pair that fulfils the last marginal quantity to meet the entire system demand.

Chart 9 shows the number of periods in which each generation company was the price setter, expressed as a percentage of the total number of periods in the month.

In 2022, the three most frequent price setters contributed to 65.77% of the periods with a price setter, a drop of 6.46 percentage points from 72.23% in 2021. The three main generation companies identified to be price setters in 2022 were G5, G3 and G4, with averages of 28.28%, 19.19% and 18.30% respectively, for all the periods with a price setter. Among the top three generation companies, G5 was most frequently the price setter in 2022, which is in line with its relatively high market share based on metered energy quantity, as shown in Table 2.

In 2022, G5 and G3 remained as the top two most frequent price setters, while G2 was replaced by G4 in the third place. This could have corresponded to a reduction in capacity due to the increased planned or unplanned maintenance. Additionally, the market observed a surge in the available CCGT capacity in excess of offer capacity especially in the second half of 2022, which might have reduced the volume of quantity that generation companies could offer in the market.

CHART 10: OFFER VARIATIONS MADE AFTER GATE CLOSURE



In accordance with the Market Rules, generation companies should submit offers within a gate closure window of at least 65 minutes before the actual trading period. Offer or bid variations made after gate closure are tracked and regularly reported to the MSCP for investigation.

Chart 10 compares the number of offer variations made after gate closure from 2018 to 2022 in relation to the number of forced outages.

From 2018 to 2022, the trend of forced outage occurrences generally correlated with the number of cases where offer variations were made after gate closure, except for 2021.

In 2021, the number of offer variations made after gate closure increased sharply, while the number of forced outages only rose slightly. This indicates that forced outage was not the primary reason for the offer variations made after gate closure in 2021.

The spike in offer variations made after gate closure coincided with the period of gas supply constraints. This indicates that the significant increase in the number of offer variations made after gate closure could be due to reduced stability in the supply system in 2021. This was due to some generation companies making more operational changes to cope with the urgent upstream gas curtailment requests.

Since then, a rule change has been established to exempt Generation Registered Facilities (GRF) undergoing a fuel changeover directed by the PSO from the Automatic Financial Penalty Scheme (AFPS).[9] Hence, for such cases, there was no need for GRF to submit offer variations after gate closure as they would not be penalised under the AFPS.

In 2022, the number of offer variations made after the gate closure window decreased to 599 from 799 in 2021 as GRF undergoing fuel changeover directed by the PSO will no longer incur financial penalties even when they do not make offer variations. Nevertheless, the offer variation after gate closure statistic is still higher than the pre-2021 level as there were 138 cases due to the PSO's directions. The number of forced outages remained constant at 63 instances in 2022.

9 Energy Market Company, 14 September 2022, "Notice of market rules modification (Paper No.: EMC/RCP/129/2022/380)".

CHART 11: SUBMISSION TIME OF OFFER VARIATIONS MADE WITHIN GATE CLOSURE

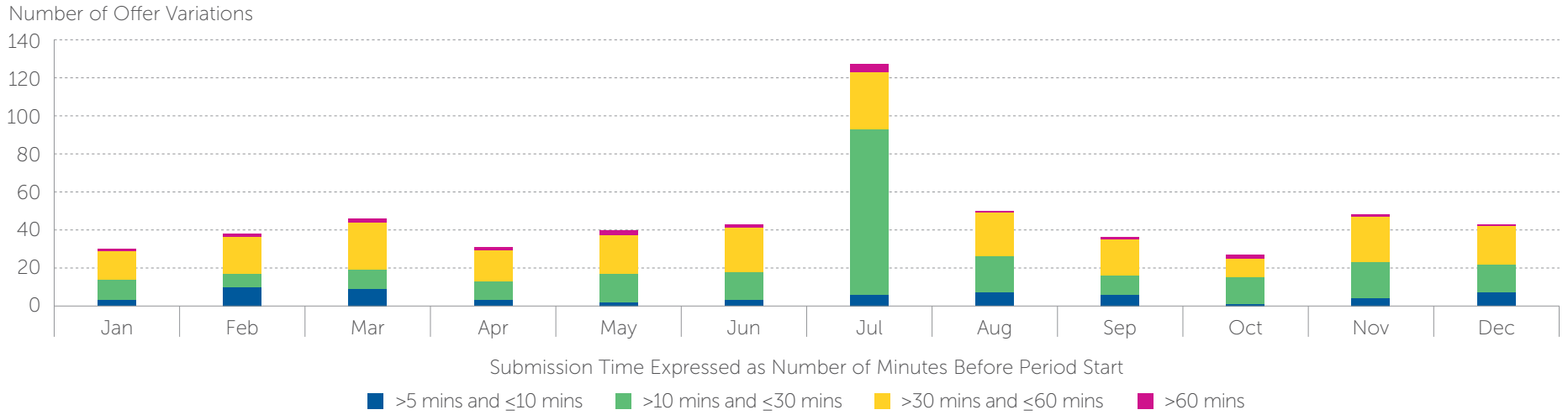
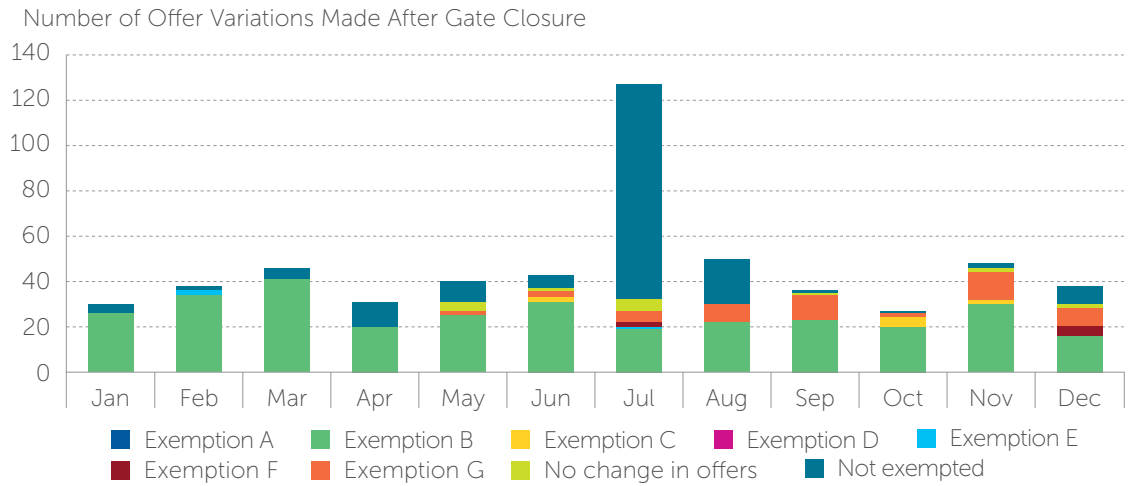


Chart 11 reflects monthly offer variations in 2022 submitted within the gate closure window or less than 65 minutes before the actual trading period, categorised by ranges of proximity of submission time to the actual trading period.

Notably, the number of offer variations made within the gate closure window increased significantly for submission time range between 10 and 30 minutes in the month of July 2022, coinciding with the relatively higher number of directions under the DSS issued to generation companies from the PSO.

Nevertheless, offer variations were submitted between 10 minutes to 65 minutes before the actual trading periods for close to 89% of the total occurrences. This indicates that generation companies were still sufficiently able to respond before the start of the actual trading period, a similar trend as observed in 2021.

CHART 12: CASES OF OFFER VARIATIONS MADE AFTER GATE CLOSURE



Under section 10.4.1 of Chapter 6 of the Market Rules, conditions have been set out as exemptions to the violation of the gate closure rules for the Generation Registered Facilities and Load Registered Facilities (please refer to Box 4 for more details on exempted cases).

Chart 12 shows that of the 552 cases[10] assessed by the MSCP in 2022, 307 cases were determined not to be in breach of the Market Rules as they were exempted under Exemption B, and 15 cases were determined not to be in breach due to offer submissions with no changes in offers.

In line with Chart 11, Chart 12 reflects an increased number of cases of violation of the gate closure rules in July 2022 due to the instability of the overall supply system in the month, which had prompted generation companies to make more submissions of last-minute offer variations.

The MSCP determinations on the gate closure violation cases assessed by the Panel are included in the State of Compliance within the Wholesale Electricity Market section of this report and have been published on the EMC website.

BOX 4. EXEMPTION CONDITIONS FOR CASES OF OFFER VARIATIONS MADE AFTER GATE CLOSURE

As provided by section 10.4.1 of Chapter 6 of the Market Rules, there are prescribed circumstances specified as exemptions for the assessment of offer variations made after gate closure, subjected to section 10.4.1.2. These exemptions are listed below:

Exemption A where an offer variation is intended for a Generation Registered Facility, to reflect its expected ramp-up and ramp-down profiles during periods following synchronisation or preceding desynchronisation.

Exemption B where an offer variation is intended for a Generation Registered Facility, to reflect its revised capability for the three consecutive dispatch periods immediately following a forced outage or its failure to synchronise.

Exemption C where an offer variation is intended for an Import Registered Facility, to reflect its revised capability for the three consecutive dispatch periods immediately following a forced outage, including (i) a forced outage of the interties connecting the Import Registered Facility to the transmission system, (ii) a forced outage or failure to synchronise of any constituent generating units in the interconnected system that form part of the Import Registered Facility, or (iii) a transmission constraint within the interconnected system.

Exemption D where an offer variation is intended to contribute positively to the resolution of an energy surplus situation pertaining to which Energy Market Company (EMC) has issued an advisory notice under section 9.3.1 of Chapter 6 of the Market Rules, by allowing for decreased supply of energy.

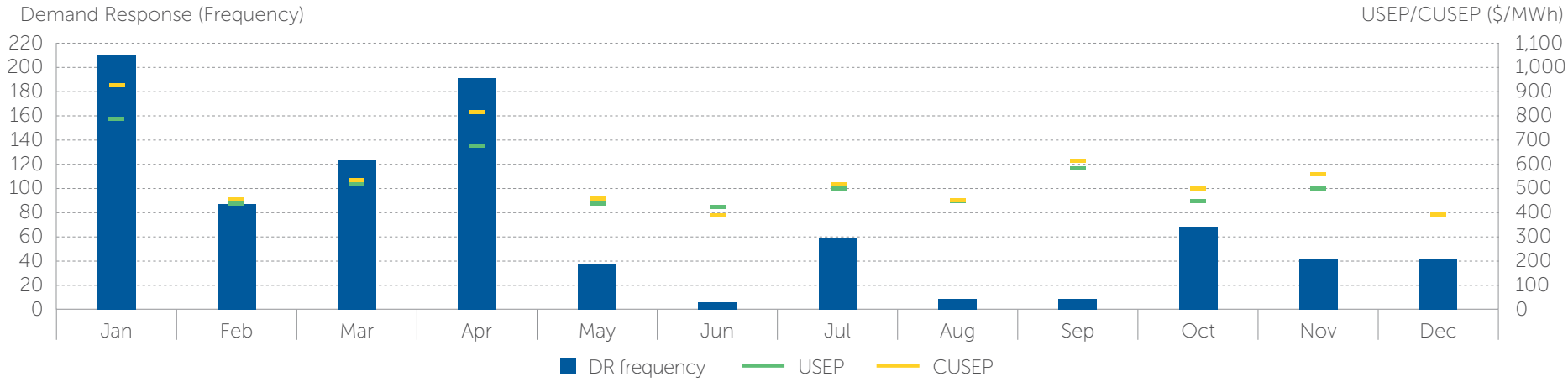
Exemption E where an offer variation is intended to contribute positively to the resolution of energy, reserve or regulation shortfall situations pertaining to which EMC has issued advisory notices under section 9.3.1 of Chapter 6 of the Market Rules, by allowing for increased supply of energy, reserve or regulation.

Exemption F where an offer variation is intended to contribute positively to the resolution of energy, reserve or regulation shortfall situations in that dispatch period, where: (i) the shortfall situations were indicated in a system status advisory notice issued by EMC in respect of a high-risk operating state or emergency operating state declared by the Power System Operator (PSO); and (ii) at the time of submission of such offer variation or revised standing offer, EMC has not yet withdrawn, in respect of that dispatch period, such system status advisory notice by allowing for increased supply of energy, reserve or regulation.

Exemption G where an offer variation is intended for a Load Registered Facility, to reflect its revised capability during a forced outage or following a decrease in energy withdrawal under sections 9.3.3 and/or 9.3.4 of Chapter 5 of the Market Rules.

10 Seven cases received in December 2022 are excluded from the statistics as they are still under investigation.

CHART 13: DEMAND RESPONSE FREQUENCY VS USEP



The Energy Market Authority (EMA) introduced the demand response (DR) programme in 2016 to enhance competition in the wholesale electricity market, ensure a means to allow electricity demand to be met effectively, and improve system reliability during periods of supply shortage.

The DR programme provides contestable consumers with the opportunity to voluntarily curtail their electricity demand in exchange for a share in system-wide benefits, in particular, from the reduction in the wholesale electricity price.

The licensed load providers are required to be compliant with 100% of the scheduled load curtailment to be paid. Licensed load providers which only partially comply with their scheduled curtailment will not be entitled to any incentive payments. Penalties will be imposed on licensed load providers which are compliant with less than 95% of their scheduled curtailment.

Since the introduction of DR in the market, there were only two successful activations in 2018, none in 2019, 23 in 2020, and 343 in 2021. In 2022, however, DR was activated for a total of 883 periods. The majority of these activations occurred from January to April 2022, coinciding with the relatively high USEP. In particular, it is noted that high DR activation usually coincides with relatively large difference between USEP and counterfactual USEP (CUSEP), as seen in January and April 2022.

As shown in Chart 13, DR activation brought about cost savings with reduced wholesale energy prices, as the USEP was usually lower than the CUSEP. The activation of DR also improved system reliability during periods of supply shortage and delivered system-wide benefits, especially in 2022.

On 3 November 2022, the EMA published a paper on enhancing the DR and interruptible load (IL) programmes through a Demand Side Management Sandbox with the aim of encouraging consumer participation.[11] The temporary sandbox scheme was launched on 1 January 2023 and will run till 31 December 2024.

11 Energy Market Authority, 3 November 2022, "Enhancing the demand response (DR) and interruptible load (IL) programmes with a demand side management sandbox".

CHART 14: COMPARISON OF ACTUAL DEMAND

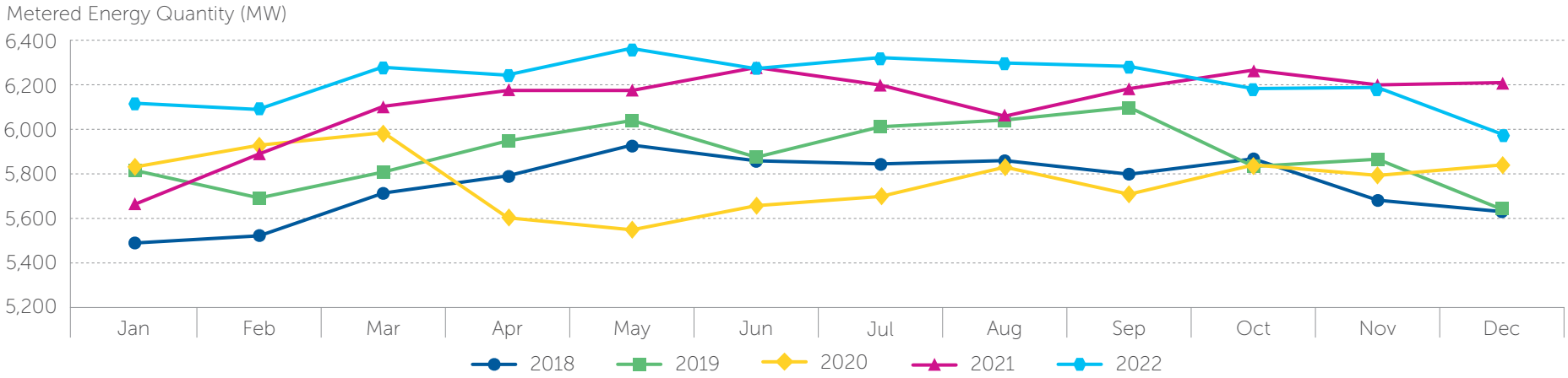


Chart 14 compares the actual demand (computed from metered energy quantity) between 2018 and 2022. Based on the yearly average, demand rose 1.66% from 6,116 MW in 2021 to 6,218 MW in 2022. This was recorded as the highest yearly average demand since the NEMS started in 2003.

In 2022, the large drop in the demand in December as compared to the other months was due to relatively lower monthly temperatures and Singapore experiencing moderate to heavy short-duration thundery showers on most afternoon in the first fortnight of the month.

The strengthened demand from April to May 2022 was due to the resumption in social and economic activities as Singapore moved from the Transition Phase to Covid-19 Resilience since 26 April 2022. In particular, the demand of 6,362 MW in May 2022 was the highest monthly average demand since 2003. The decline in the demand from July to October 2022 was largely due to the cooler weather that Singapore experienced as demand tends to move in tandem with temperature.

The monthly average demand in 2022 was highest in the past five years for most of the months – except for June, October and December. In 2022, the highest annual increase in demand of 8% was recorded in January, largely due to the relaxation of Covid-19 measures at the start of 2022, associated with the high vaccination rate of the Singapore population, and the economy recovering from the impact of the Covid-19 pandemic.

TABLE 8: VARIATION IN LOAD FORECAST (MW)

Year	Variation between PDS & Real-Time		Variation between STS & Real-Time	
	Mean	Standard Deviation	Mean	Standard Deviation
2018	57.97	40.67	16.82	14.31
2019	55.78	40.42	15.58	11.30
2020	53.98	40.13	14.94	11.01
2021	75.33	49.72	20.86	13.55
2022	61.58	42.58	17.41	14.22

In the NEMS, three forecast schedules with different forecast horizons are made available to MPs, namely the Market Outlook Scenario (MOS), the Pre-dispatch Schedule (PDS), and the Short-term Schedule (STS). The MOS is updated every day with a forecast horizon of six days, the PDS is updated every two hours with a forecast horizon of 12 to 36 hours, and the STS is updated every half hour with a forecast horizon of six hours. The accuracy of the forecast schedules is essential for the efficient operation of the market, as it determines the responsiveness of generation facilities to real-time demand conditions.

Table 8 shows the accuracy of the forecast schedules for the past five years, measured by the mean and standard deviation of the load variations in the PDS and the STS, when compared to the real-time dispatch schedule.[12] As the STS is generated more frequently and closer to the real-time dispatch period than the PDS, the load variation between the STS and the real-time dispatch schedule tends to be smaller than that between the PDS and the real-time dispatch schedule.

In 2022, the mean load variation between the PDS and the real-time dispatch schedule was 61.58 MW, 3.54 times as large as that between the STS and the real-time dispatch schedule. Correspondingly, the standard deviation of the load variation between the PDS and the real-time dispatch schedule in 2022 was 42.58 MW, which was 2.99 times as large as that between the STS and the real-time dispatch schedule.

The mean load variation between the PDS and real-time dispatch schedule in 2022 was 18.25% lower than that in 2021, indicating a higher accuracy in the PDS. The mean load variation between the STS and real-time dispatch schedule reduced by 16.53% in 2022, indicating that there was an improved accuracy in the STS as well.

TABLE 9: VARIATION IN REAL-TIME LOAD FORECAST (%)

Year	Variation between Real-Time Load Forecast & Actual Demand	YOY Change
2018	2.58	0.32
2019	2.46	-0.12
2020	2.16	-0.30
2021	1.72	-0.44
2022	1.50	-0.21

For real-time dispatch schedules, the accuracy of the load forecast is crucial as the load forecast is used to determine dispatch instructions and market prices. The more accurate the load forecast is, the more reflective the dispatch instructions and market prices are of actual system conditions. Therefore, it is important to maintain an accurate load forecast to achieve system stability and efficient pricing outcomes.

A small variation between the real-time load forecast and actual demand is expected. There are a few factors contributing to this variation. For example, the real-time load forecast includes the station and auxiliary loads, while the metered energy quantity, which is based on settlement data furnished by the Market Support Services Licensee (MSSL), omits these components. This difference in methodology creates a variation between the real-time load forecast and the actual demand, with the real-time load forecast being higher than the actual demand. Other possible reasons for the variation between the real-time load forecast and the actual demand are metering errors and transmission losses.

Table 9 presents the variation between the real-time load forecast and the actual demand, which indicates the average load forecast deviation. This deviation has remained below 3.00% for the past five years, from its lowest level at 1.50% in 2022 to its highest at 2.58% in 2018.

Since 2018, the variation between the real-time load forecast and the actual demand has been on a downward trend, showing improvement in the real-time load forecast – the lower the variation, the more accurate the load forecast. The variation between the real-time load forecast and the actual demand decreased 0.21 percentage point to 1.50% in 2022, from 1.72% in 2021. This was the lowest variation observed since the NEMS started, implying an improvement in the accuracy of the real-time forecast.

12 The real-time dispatch schedule is generated 30 seconds before each dispatch period and covers the associated dispatch period.

CHART 15: LVP VS MONTHLY VOLUME-WEIGHTED AVERAGE WEP (VWA-WEP)[13]

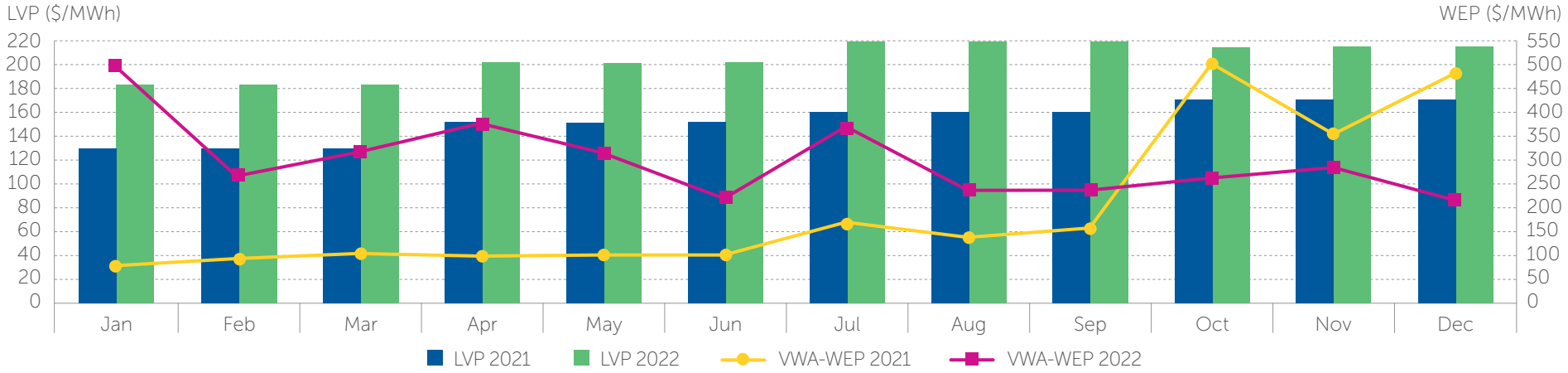


Chart 15 shows the LNG Vesting Price (LVP)[14] and the monthly volume-weighted average Wholesale Electricity Price (WEP) for 2021 and 2022. As the LVP reflects the long run marginal cost of a generation facility, the WEP should follow the LVP closely in an efficient market. It is noteworthy that the volume-weighted average WEP for some of the months in 2022 did not follow closely to the LVP. This could be attributed to the price volatility experienced in the market arising from tighter supply conditions and higher fuel cost.

In 2022, the monthly volume-weighted average WEP was higher than that in 2021 for a significant part of the year – from January to September. This was mainly driven by the recovery of Singapore's economy on the back of the relaxation of Covid-19 restrictions applied in 2021 and attributed to the growth in electricity demand.

Another driver that explains the increase in the monthly volume-weighted average WEP was the higher level of fuel oil prices observed in 2022 as compared to 2021.

As for the remaining months – from October to December, the monthly volume-weighted average WEP was lower than that in 2021. This was attributed to the disruption to Singapore's piped natural gas supply due to the global energy crunch[15] in 2021 which sent the fuel prices and WEP spiralling upwards.

The largest annual change hike in the monthly volume-weighted average WEP was recorded in January, when the WEP increased 532.44% to $498.31/MWh, from $78.79/MWh in January 2021. This was also the highest monthly recorded WEP for 2022. The rocketing WEP was due to the limited capacity supply available as there was higher planned maintenance causing a tighter supply cushion for the month of January.

Given the prolonged duration of higher WEP in 2022 due to the tighter supply observed in the market, the annual volume-weighted average WEP surged 51.07% to $300.07/MWh in 2022 from $198.63/MWh in 2021. The yearly volume-weighted average WEP was 46.65% higher than the yearly average LVP in 2022.

The LVP increased 33.77% to $204.62/MWh in 2022 from $152.96/MWh in 2021 while the volume-weighted average WEP was higher than the LVP as the WEP increased by a greater magnitude from January to November.

13 Due to adjustments in the calculation methodology, the monthly volume-weighted average WEP for 2021 has been adjusted.

14 The Vesting Contract Hedge Price (VCHP) was made up of the Balance Vesting Price (BVP) and the LVP, which are differentiated based on the primary fuel source, piped natural gas or liquefied natural gas (LNG). However, since the Balance Vesting Quantity was reduced to zero and the BVP was removed accordingly on 1 July 2019, the VCHP has depended solely on the LVP.

15 Energy Market Authority media release, 19 October 2021, "Pre-emptive Measures to Enhance Singapore's Energy Security and Resilience".

CHART 16: INDEX OF LVP, WEP, FUEL OIL PRICE AND ELECTRICITY TARIFF

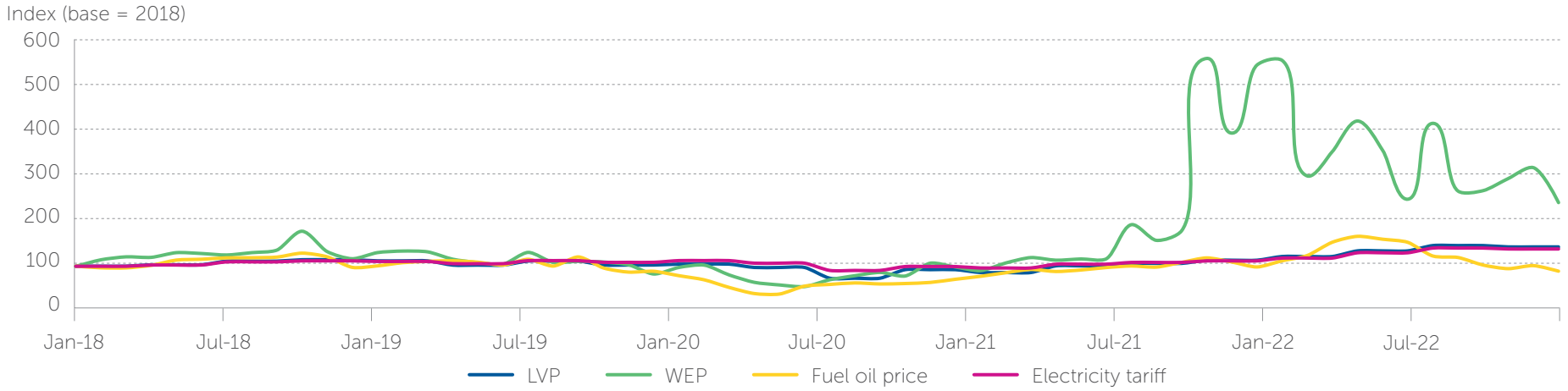


Chart 16 shows the relative changes in the LVP, the WEP, the fuel oil price and the electricity tariff for the past five years, expressed as indices against the prices in the base year 2018.

Throughout the review period from January 2018 to June 2021, the WEP moved in tandem with the fuel oil price, implying that the fuel oil price was a factor which could account for changes in the WEP.

On a yearly comparison, the fuel oil price surged 28.49% to US$522.73/MT in 2022, from US$406.81/MT in 2021, and the WEP soared 49.74% to $292.91/MWh in 2022, from $195.62/MWh in 2021. These are the highest yearly fuel oil price and WEP levels recorded since the start of the market.

2022 was a year of higher planned and unplanned maintenance levels resulting in tighter supply conditions, with the supply cushion below the 20% mark, that resulted in multiple periods of high energy prices observed throughout the year.

Additionally, an increase in demand also contributed to the volatility of the WEP. However, since August 2022, the WEP showed a downward trend as compared to the first half of the year following a moderation in the fuel oil prices.

The LVP and the electricity tariff are expected to move in the same direction as they are representations of the cost of generating electricity in the NEMS, as seen from 2018 to 2022. The electricity tariff gradually increased 16.90% to $0.32/kWh in Q4 2022[16] from $0.27/kWh in Q1 2022.[17]

16 SP Group media release, 30 September 2022, "Electricity tariff revision for the period 1 October to 31 December 2022".

17 SP Group media release, 30 December 2021, "Electricity tariff revision for the period 1 January to 31 March 2022".

TABLE 10: MONTHLY AVERAGE CORRELATION COEFFICIENT OF WEP AND METERED ENERGY QUANTITY

Month	2021			2022		
	Correlation Coefficient, *r*	r^2	Number of Days With *r*>0.5	Correlation Coefficient, *r*	r^2	Number of Days With *r*>0.5
Jan	0.79	0.63	29	0.63	0.39	24
Feb	0.67	0.45	25	0.67	0.45	22
Mar	0.72	0.52	28	0.64	0.41	21
Apr	0.27	0.07	6	0.54	0.30	19
May	0.11	0.01	4	0.59	0.35	21
Jun	0.43	0.19	16	0.75	0.56	28
Jul	0.49	0.24	17	0.69	0.48	25
Aug	0.36	0.13	15	0.78	0.60	27
Sep	0.39	0.15	12	0.74	0.54	25
Oct	0.42	0.18	11	0.81	0.65	30
Nov	0.44	0.20	13	0.80	0.63	27
Dec	0.26	0.07	4	0.83	0.68	28
Average/Sum	**0.45**	**0.24**	**180**	**0.71**	**0.50**	**297**

Table 10 shows the correlation coefficient *r* which measures the strength of the relationship between the WEP and the metered energy quantity (actual demand) and ranges from -1 to 1. A positive *r* indicates a positive relationship between the two variables (e.g. as demand rises, the WEP also rises). A negative *r* indicates an inverse relationship between the two variables (e.g. as demand rises, the WEP falls). A low r in either direction indicates a weak correlation between the WEP and demand while a high *r* in either direction indicates a strong correlation. The square of the correlation coefficient r^2 is the proportion of the variance in the WEP which could be explained by variations in demand.

The monthly *r* value in 2022 was between 0.54 to 0.83, which implies an overall improvement in the strength of the relationship between the WEP and the metered energy quantity when compared to 2021, which recorded a range of 0.11 to 0.79. The yearly average r value rose to 0.71 in 2022 from 0.45 in 2021, and the number of days when r was greater than 0.5 went up to 297 days in 2022 from 180 days in 2021. This implies that the correlation between the WEP and the metered energy quantity is stronger as there were more instances in 2022 of the WEP and the metered energy quantity moving in tandem as compared to 2021.

The r^2 value increased to 0.50 in 2022 from 0.24 in 2021. This meant that 50.50% of the variance in the WEP in 2022 could be attributed to variations in the demand, compared to 23.72% in 2021.

CHART 17: CORRELATION BETWEEN WEP AND METERED ENERGY QUANTITY IN 2022

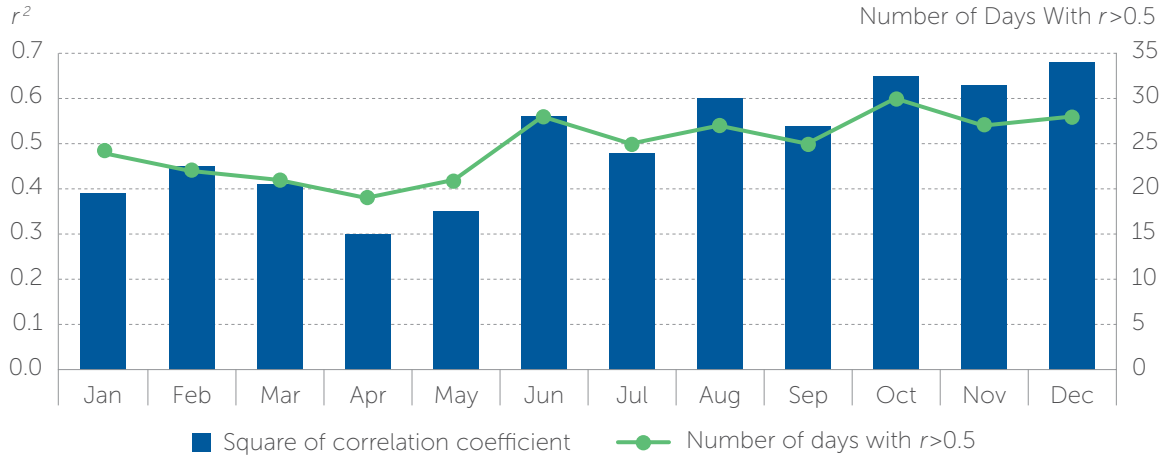


Chart 17 shows the correlation between the WEP and the metered energy quantity in 2022. Generally, the r^2 value positively correlates to the number of days when the r value is greater than 0.5.

The highest r^2 value recorded in 2022 was 0.68 in December 2022, when there were 28 days with r value greater than 0.5, only three days short of a complete month. This indicates that the WEP observed for most of the days of December 2022 was largely driven by the changes in demand. The lowest r^2 value in 2022 was recorded at 0.30 in April 2022 with 19 days with the r value greater than 0.5.

From January to May 2022, there were fewer than 24 days with an r value greater than 0.5 and r^2 value lesser than 0.5. As the WEP is also dependent on factors such as fuel oil price, outage level, supply cushion, and generators' offers, the impact on the WEP could have been dampened by movements in these variables resulting in a weaker correlation.

CHART 18: CORRELATION BETWEEN WEP AND METERED ENERGY QUANTITY FOR 2018-2022

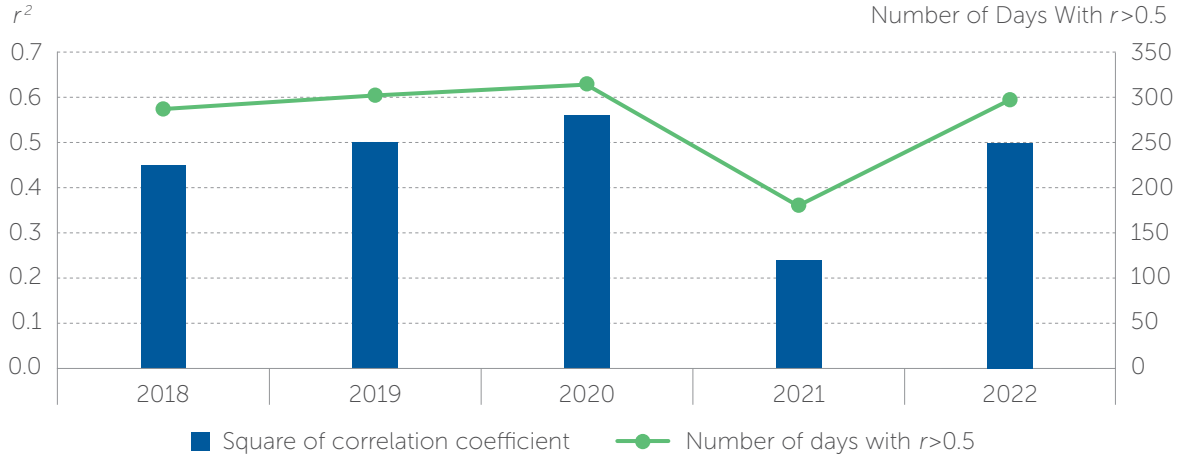


Chart 18 shows the correlation between the WEP and the metered energy quantity for the past five years. From 2018 to 2022, the r^2 value and the number of days with r value greater than 0.5 moved in tandem. In 2022, the r^2 value rose to 0.5 and the number of days with an r value greater than 0.5 spiked to 297, indicating the growing influence of demand on energy prices.

This was similar to what was observed from 2018 to 2020 where the number of days with an r value greater than 0.5 were about 300; 287 in 2018 before exceeding 300 in 2019 and 2020. This contrasts with what was observed in 2021, when the number of days with an r value greater than 0.5 dipped to 180. Given an r^2 value of 0.24 in 2021, changes in demand could account for about 23.72% of the WEP's movements in 2021. The r^2 value went up to 0.50 in 2022, which meant that changes in demand could only explain as much as 50.50% of the WEP's movements in 2022.

CHART 19: PERCENTAGE OF HOURS WHEN THE WEP FALLS INTO A PARTICULAR PRICE RANGE

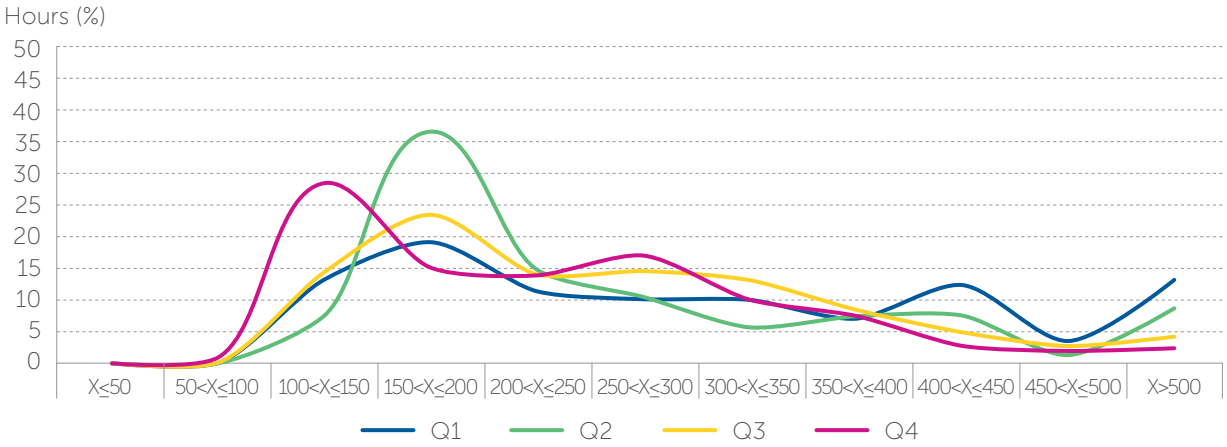


Chart 19 shows the frequency of the WEP in various price ranges, measured as a percentage of the total number of hours in each quarter of 2022. The price distribution shifted rightward from Q1 to Q2 2022 and gradually shifted leftward for Q3 and Q4 2022. This might be attributed to the EMA's new measures to safeguard the NEMS energy security, which consequently dampened the wholesale prices in the second half of the year.

In Q1 2022, Q2 2022 and Q3 2022, the distribution of the WEP remained within the $150/MWh to $200/MWh tranche for most of the time. However, in Q1 2022, the percentage of WEP distribution in the above $500/MWh tranche was the highest among all quarters. In Q4 2022, the peak of the distribution further shifted to the lower price tranches, skewing towards the $100/MWh to $150/MWh tranche during more instances. This is associated with a lower average WEP during Q4 2022.

CHART 20: PERCENTAGE OF ENERGY QUANTITY WHEN THE WEP FALLS INTO A PARTICULAR PRICE RANGE

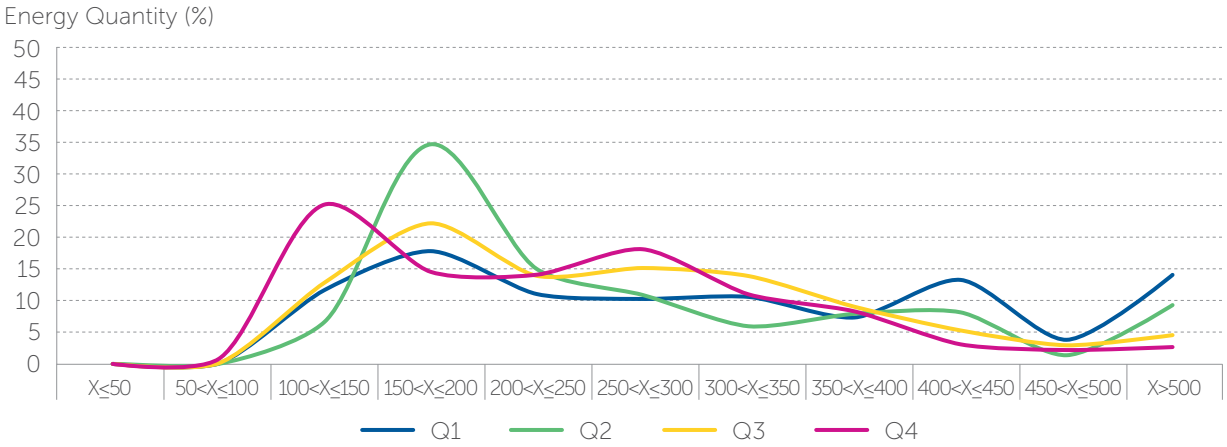


Chart 20 shows the frequency of the WEP in various price ranges, measured as a percentage of the total metered energy quantity in each quarter of 2022.

During 2022, the WEP was observed moving to the lower price tranches over a higher metered energy quantity during more instances from Q1 and Q2 to Q3 and Q4, however, covering a slightly lower percentage of the total metered energy quantity.

It is observed that the distribution of WEP based on a percentage of hours and the distribution of WEP over total metered energy quantity show a similar change in the price distribution reflecting that the WEP and the demand may have remained low throughout the day except for a few peak hours of high demand, reflecting the narrow range of the metered energy quantity seen in the NEMS.

PRICE INDICES: FREQUENCY DISTRIBUTION OF WEP BY (A) PERCENTAGE OF HOURS OF OCCURRENCE AND (B) PERCENTAGE OF ENERGY QUANTITY AFFECTED

CHART 21: PERCENTAGE OF HOURS WHEN THE WEP FALLS INTO A PARTICULAR PRICE RANGE

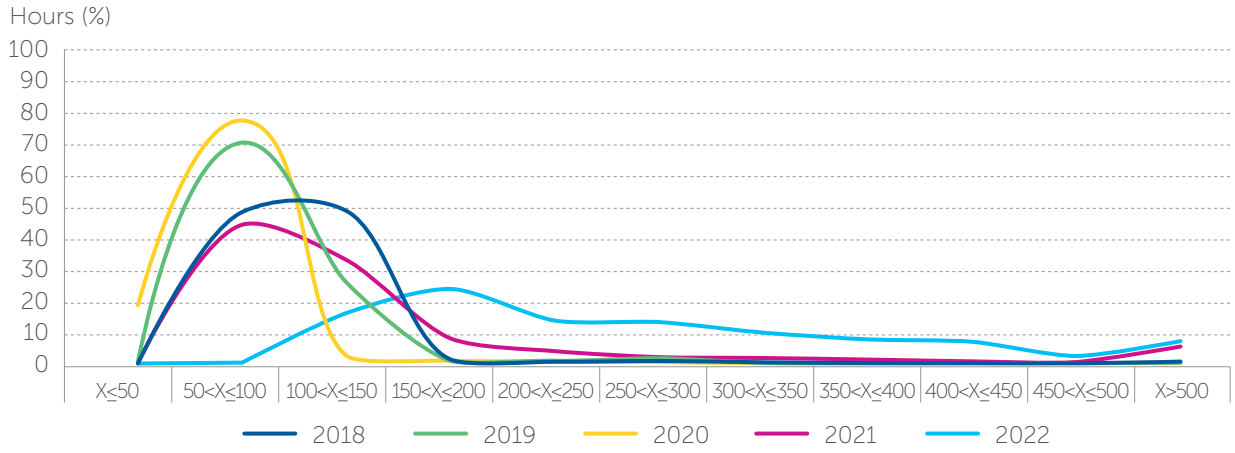


Chart 21 shows the historical price distribution for the past five years expressed as a percentage of the total number of hours in each year, to examine longer term trends.

In 2018, the distribution of the WEP shifted leftward with the WEP clearing mostly between $100/MWh and $150/MWh. The WEP then further shifted to a lower price tranche in 2019, 2020 and 2021, with the frequency of WEP ranging between $50/MWh and $100/MWh for most of the time.

In 2022, the distribution of the WEP shifted rightward towards the higher price tranches, largely clearing between $150/MWh and $200/MWh. However, the frequency of the WEP clearing above $500/MWh was the highest recorded over the five years. We observed a significantly flatter peak distribution in 2022, which could be attributed to the effect of the PSO/EMA's directions.

CHART 22: PERCENTAGE OF ENERGY QUANTITY WHEN THE WEP FALLS INTO A PARTICULAR PRICE RANGE

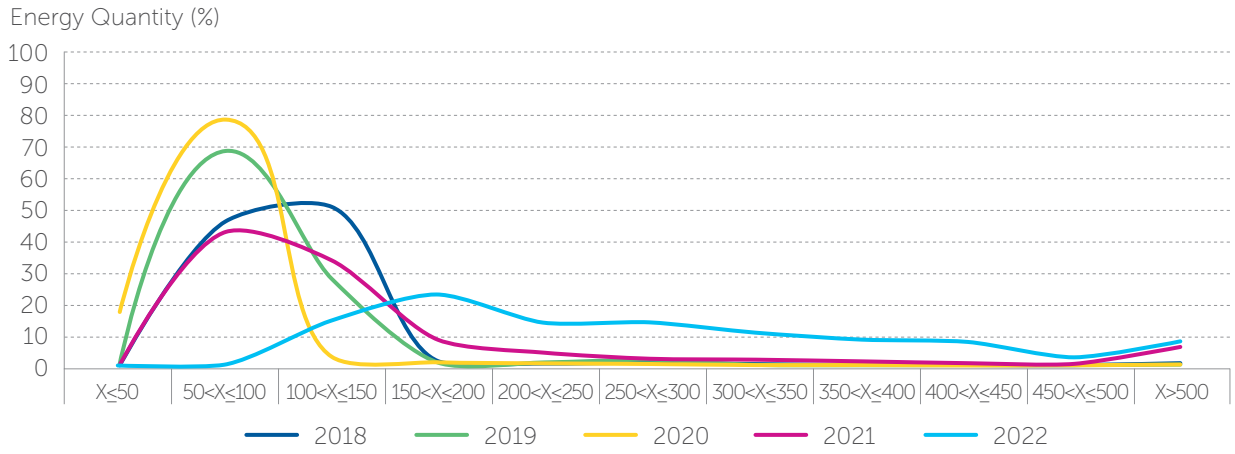


Chart 22 shows the historical price distribution for the past five years, based on the percentage of the total metered energy quantity.

The behaviour of the price distribution based on energy quantity reflects the narrow range of the metered energy quantity across the periods observed in the NEMS as the metered energy quantity may have maintained at a similar profile throughout the day with slight volatility on exceptional days.

TABLE 11: VARIATION IN REAL-TIME USEP IN 2022 ($/MWH)

Month	Variation between STS & Real-Time
Jan	5.30
Feb	-2.21
Mar	3.48
Apr	28.47
May	2.26
Jun	-3.25
Jul	1.17
Aug	4.79
Sep	-2.43
Oct	1.08
Nov	11.20
Dec	-2.55

Table 11 shows the difference in the USEP produced in the STS and the real-time dispatch schedule as a monthly average variation in 2022. A positive variation means the real-time dispatch schedule has a higher USEP than the STS, while a negative variation means the real-time dispatch schedule has a lower USEP than the STS.

In October 2022, the forecast prices generated in t he STS were close to the real-time USEP – $1.08/MWh below the real-time USEP on average. April 2022 recorded the largest monthly average variation in the USEP, when the real-time USEP was $28.47/MWh more than the forecast USEP.

Overall, the average variation between the USEP in the STS and that in the real-time dispatch schedule in 2022 was $5.68/MWh, which meant that the forecast USEP in the STS is less indicative of the real-time USEP.

CHART 23: PRIMARY RESERVE PRICE

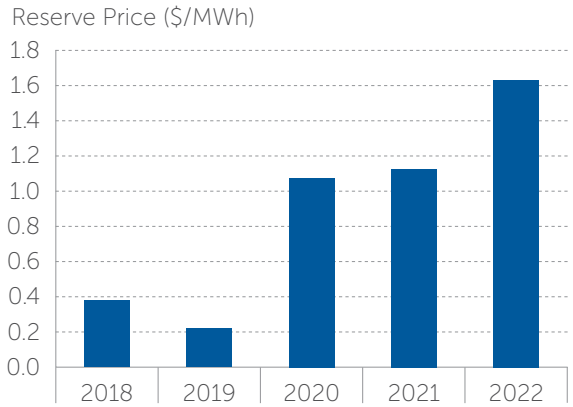


Chart 23 shows the average primary reserve price in the NEMS from 2018 to 2022.

Each registered facility offering primary reserve in the NEMS must be capable of achieving its scheduled megawatt response automatically without further instruction from the PSO within nine seconds of being triggered by any contingency event and must be able to maintain that scheduled megawatt response for ten minutes from the time it was triggered.[18]

The significant increase in the reserve price from 2019 to 2020 was due to a higher Risk Adjustment Factor (RAF) for primary reserve requirement from 1.00 to 2.00 that resulted in a higher primary reserve requirement. Since 2020, the yearly average primary reserve price has remained between $1.00/MWh and $1.70/MWh despite the declining primary reserve requirement. 2022 recorded a few instances of primary reserve shortfalls in a context of high price volatility. The highest primary reserve price increased 43.15% to $1.64/MW from 2021.

18 As required in section A.2 of Appendix 5A of the Market Rules.

CHART 24: CONTINGENCY RESERVE PRICE

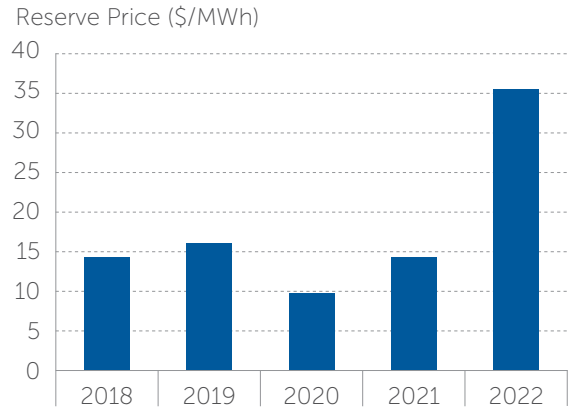


Chart 24 shows the average contingency reserve price in the NEMS for the past five years.

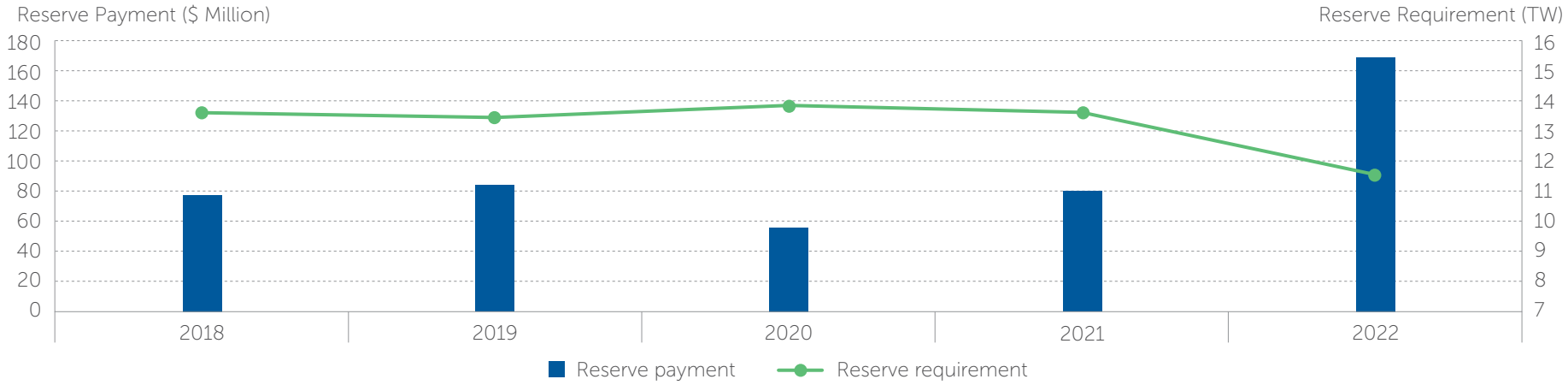
Each registered facility offering contingency reserve must be capable of achieving its scheduled megawatt response within ten minutes of being instructed to do so, and must be able to maintain its scheduled megawatt response for not less than 30 minute.[19]

From 2018 to 2021, the yearly average contingency reserve price was below $20/MWh, while in 2022, the yearly average contingency reserve price increased to $36.11/MWh. The average contingency reserve price in 2022 was the highest level seen since the market started.

The contingency reserve requirement dropped by 17.96% in 2022 as compared to 2021 due to the reduction in the Risk Adjustment Factor (RAF) for contingency reserve requirement from 1.5 to 1.0 since 8 July 2022. However, the yearly average contingency reserve price went up to $36.11/MWh, an increase of 250.21% from $14.43/MWh in 2021. This was in line with an increase in the number of contingency reserve shortfalls in the NEMS from 63 instances in 2021 to 680 instances in 2022, causing an increased volatility in the contingency reserve price.

19 As required in section A.2.4 of Appendix 5A of the Market Rules.

CHART 25: RESERVE PAYMENT AND REQUIREMENT



Note: GST not included in the calculation for reserve payment

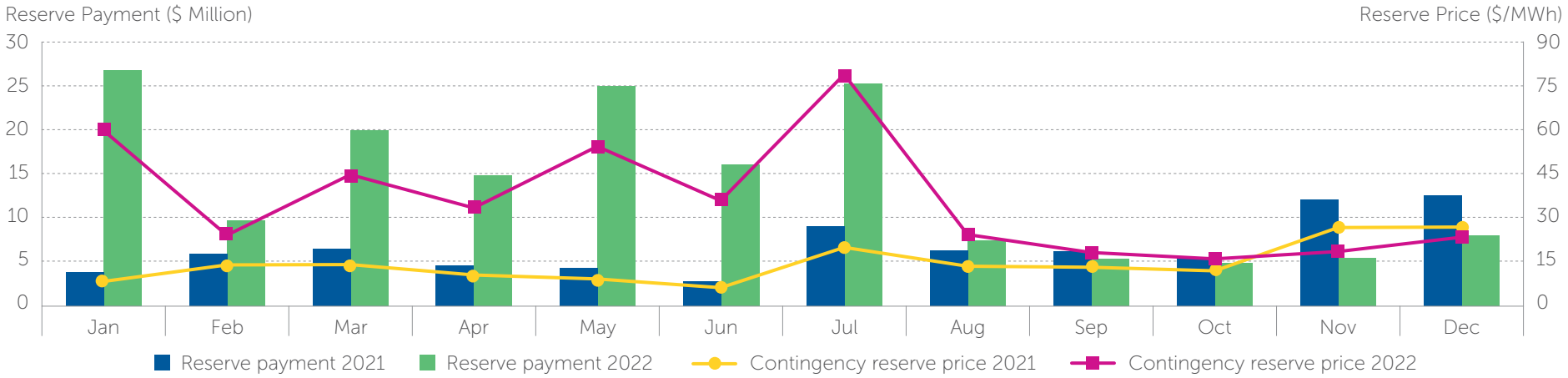
Chart 25 shows the total payment and requirement for primary and contingency reserve in the NEMS between 2018 and 2022.

The reserve requirement moved in the opposite direction of the reserve payment and has been on a downward trend since 2020.

The primary and contingency reserve requirement fell by 5.70% and 17.96% respectively. The significant reduction in the contingency reserve requirement this year was due to a downward revision of the Risk Adjustment Factor (RAF) for contingency reserve, from 1.5 to 1.0 since 8 July 2022.

As explained in the primary and contingency reserve price sections, despite the reserve requirement shrinking in 2022, reserve prices rose. This propelled the reserve payment up to $169.06 million for the year, with the higher contingency reserve price contributing a larger proportion to the increase. This was the second consecutive year that the market observed a rise in the reserve payment.

CHART 26: RESERVE PAYMENT AND CONTINGENCY RESERVE PRICE



Note: GST not included in the calculation for reserve payment

Chart 26 compares the reserve payment against the contingency reserve price between 2021 and 2022 on a monthly average basis.

The monthly average contingency reserve price, which ranged from $15.88/MWh to $79.03/MWh, was the main driver of the total reserve payment. The primary reserve price, which remained below $8/MWh for all months, contributed minimally to the total reserve payment. Hence, a large part of the monthly reserve payment was influenced by movements in the contingency reserve price.

There were ten months in 2022 with the contingency reserve price being greater than that in 2021, and a higher total reserve payment was reported for eight months. The reserve payment from August onwards was lower compared to the previous year, dropping below $10 million likely due to the changes in the contingency reserve requirement.

In November and December 2022, the contingency reserve prices were lower than those for the corresponding months in 2021 due to the price volatility observed in the energy market. Consequently, the reserve payment recorded for 2022 for those months was lower than in 2021.

TABLE 12: IL ACTIVATIONS FOR CONTINGENCY RESERVE MARKET

Month	2021		2022	
	Instances of IL Activation	Number of Periods of IL Activation	Instances of IL Activation	Number of Periods of IL Activation
Jan	0	0	1	1
Feb	0	0	0	0
Mar	0	0	0	0
Apr	0	0	0	0
May	0	0	0	0
Jun	1	1	0	0
Jul	0	0	2	7
Aug	0	0	3	7
Sep	1	1	2	3
Oct	1	2	1	2
Nov	1	2	3	5
Dec	0	0	1	2
Sum	4	6	13	27

Table 12 compares the interruptible load (IL)[20] activations to provide contingency reserve between 2021 and 2022.

There were more IL activations in 2022 than in 2021 – 13 compared to 2021's four activations.

The duration of the activations, measured by the number of periods of IL activations, increased to 27 in 2022. The IL activation with the longest duration occurred on 27 July 2022, consisting of five periods. During the second half of the year, more instances of IL activations were observed.

These IL activations likely occurred to make up for the tight supply in the system when high numbers of facilities are on outage during those periods.

20 An IL provider offers its load or the load of its customers to be interrupted in exchange for reserve payments under the interruptible load scheme. An IL provider is required to hold a Wholesaler (Demand Side Participation) Licence issued by the Energy Market Authority.

CHART 27: PERCENTAGE CONTRIBUTION FROM IL FOR THE TWO CLASSES OF SCHEDULED RESERVE

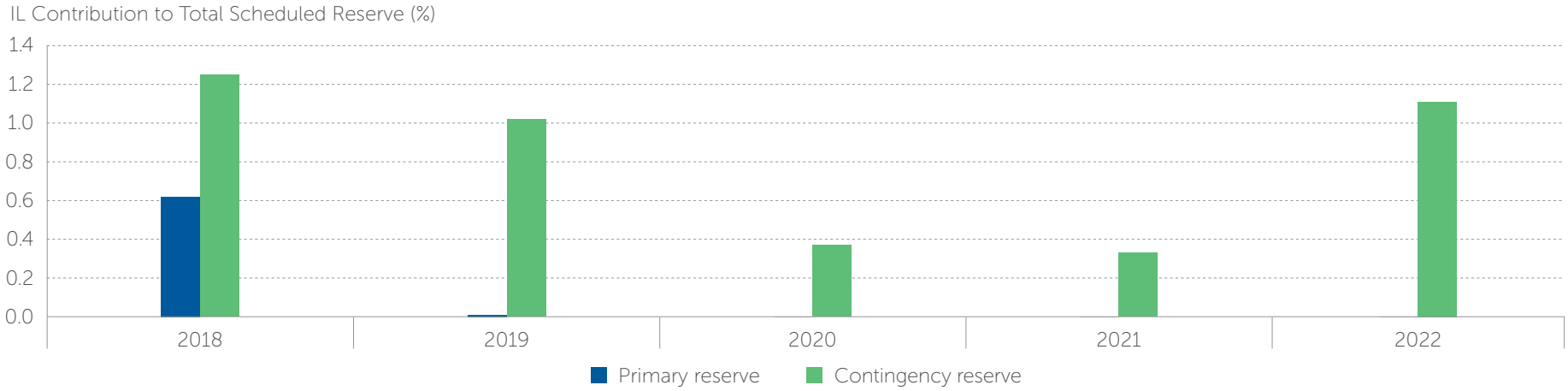


Chart 27 shows the contribution of IL to primary and contingency reserves in the past five years.

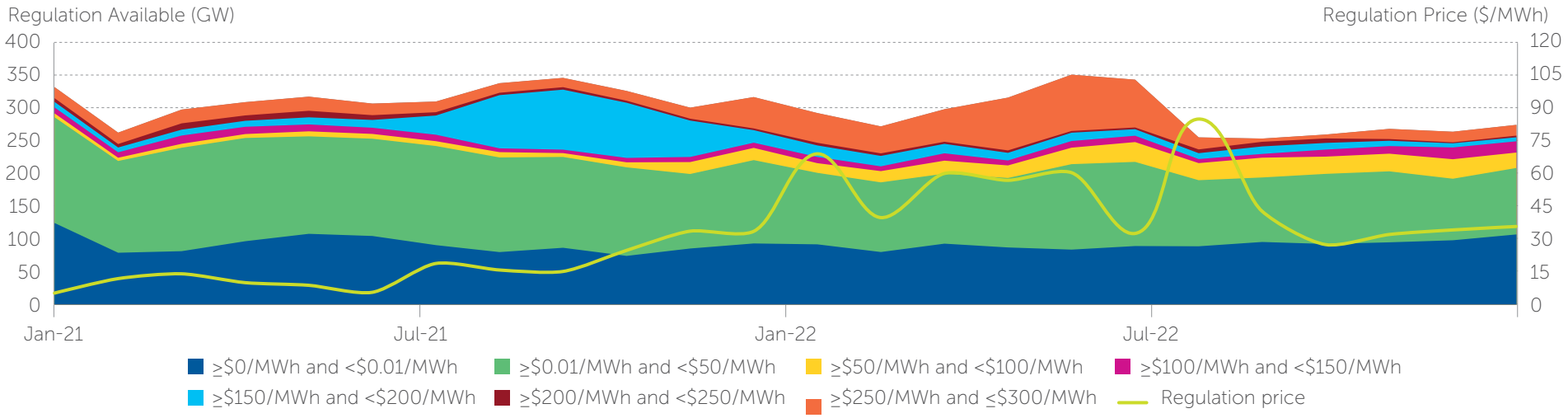
In 2018, the contribution of IL to primary reserve was 0.62%. It then contracted to 0.01% in 2019 and was eventually 0.00% from 2020 onwards. The decreased contribution since 2018 was due to a reduction in the number of IL facilities which were eligible to provide primary reserve, from two to one.

The remaining IL facility did not submit offers into the market for most of 2019 and eventually de-registered from the NEMS on 5 October 2019. Hence, there are no IL facilities providing primary reserve from 2020 onwards.

In 2018, the percentage contribution of IL to the contingency reserve class was at its highest level among the five years at around 1.25%. Since then, the percentage of IL to the contingency reserve has been on a downward trend, moving from 1.25% in 2018, to 1.02% in 2019, then from 0.37% in 2020 down to 0.33% in 2021.

However, in 2022, the contribution of IL to the contingency reserve increased to 1.11%, due to more periods of IL activation from generation facilities.

CHART 28: REGULATION AVAILABILITY VS REGULATION PRICE



The monthly aggregated regulation quantity offered at various price ranges and the monthly regulation price for 2021 and 2022 are shown in Chart 28. The yearly average regulation price rose in 2022 due to fluctuations in the energy price. The monthly regulation price ranged from $5.19/MWh to $33.60/MWh in 2021, and increased to between $27.44/MWh and $85.04/MWh in 2022.

In 2022, the regulation availability shrank 8.37% while the regulation requirement increased 4.52%. As a result of the weaker supply amidst stronger requirement for regulation, the yearly average regulation price rose almost three-fold to $48.02/MWh in 2022 from $16.41/MWh in 2021. This was attributed to the price volatility observed in the first half of the year.

The largest increase was recorded in the "≥$50/MWh and <$100/MWh" tranches, where the proportion of offers was 179.43% higher than in 2021. The largest decrease was observed in the "≥$150/MWh and <$200/MWh" tranche, where the proportion of offers was 68.04% lower than in 2021. The regulation offers from the lower price tranches (less than $50/MWh) were redistributed to the middle price tranches (between $50/MWh and $150/MWh).

For the first half of the year, there were more instances of regulation shortfall accompanied by higher prices for those months. In July 2022, the regulation price peaked at $85.04/MWh amidst a 25.68% drop in the regulation availability compared to June 2022 and increased price volatility due to tighter market conditions.

ECONOMETRIC MODEL AND OUTLIER PRICES

To identify and analyse outlier occurrences of the Uniform Singapore Energy Price (USEP), the Market Surveillance and Compliance Panel (MSCP) uses an econometric model[21] as a means of estimating the dependent variable USEP through the use of independent variables, including the Combined Cycle Gas Turbine (CCGT) supply, Steam Turbine (ST) supply, energy supply cushion, offers below $100 per megawatt hour (MWh), energy demand, reserve cushion and lagged fuel oil prices. The model is also adjusted to distinguish planned and forced outages between generation types and address seasonality. Given the introduction of new generation types in 2022, such as Electricity Imports (Import) and Energy Storage System (ESS), the Market Assessment Unit (MAU) adjusted the model to incorporate the effect of these new variables from this year onward.[22]

In 2020, the MSCP engaged the Head of Economics of the School of Social Sciences at Nanyang Technological University (NTU), Associate Professor Feng Qu, and PhD candidate Zhou Shihao to improve the robustness of the econometric model and propose relevant variables and approaches for the identification of USEP outliers. The revised econometric model was approved by the MSCP and has been incorporated in the MSCP Annual Report since 2020.

Table 13 shows the estimation results for the three most explanatory variables detected by the revised econometric model for January 2003 to December 2022.

Given that all variables are log-transformed, Table 13 provides the following observations for Jan 2003 – Dec 2021:

A positive coefficient indicates a direct relationship between the variable and the USEP; when the variable increases, the USEP rises as well. A negative coefficient indicates an inverse relationship between the variable and the USEP; when the variable increases, the USEP falls instead.

TABLE 13: ESTIMATION RESULTS

Variable	Coefficient
	Jan 2003 – Dec 2022
Constant	11.00
LOG (Supply Cushion)	-1.80
LOG (Demand)	0.68
LOG (Offers Below $100/MWh)	-0.54

TABLE 14: MODEL DIAGNOSTICS

Model Diagnostics	Jan 2003 – Dec 2021	Jan 2003 – Dec 2022
R^2	0.84	0.85
Number of Observations	6,694	7,059

Given that all variables are log-transformed, Table 14 provides the following observations for January 2003 – December 2022:

- a 1% increase in supply cushion lowers the USEP by 1.80%;
- a 1% increase in demand raises the USEP by 0.68%; and
- a 1% increase in offers below $100/MWh lowers the USEP by 0.54%.

The level of statistical significance of the variables, measured as the P-value for the three coefficients in Table 13, is less than 0.01. This indicates that the three selected variables play a significant role in explaining variations in the USEP as the value represents a less than 1% chance of the variables not explaining the changes in the USEP during 2022.

Table 14 shows the model diagnostics represented by R2 for the periods January 2003 to December 2021 and January 2003 to December 2022.

The R2 value measures the proportion of the variation in the dependent variable (USEP) explained by the independent variables (e.g. supply cushion, demand and offers below $100/MWh).

The econometric model studied 7,059 observations, using data from January 2003 to December 2022, and yielded an R2 value of 0.85, which means that 85% of the changes in the USEP can be explained by changes in the supply cushion, demand, and offers below $100/MWh. The R2 value climbed one percentage point from 2021, which implied that the econometric model had a slightly improved explanatory power in 2022. Apart from adjustments to the econometric model, the additional 365 observations from 2022 also contributed to the improved R2 value.

21 Further details on the revised econometric model are available in Econometric Model Design, Approach and Methodology Report – A Review of the Current Methodology.

22 In 2022, further adjustments were made to the model to account for the impact of new technologies – Electricity Imports and ESS.

ECONOMETRIC MODEL AND OUTLIER PRICES

IDENTIFICATION OF OUTLIER PRICES

CHART 29: ACTUAL VS PREDICTED LOG USEP WITHIN THREE STANDARD DEVIATIONS

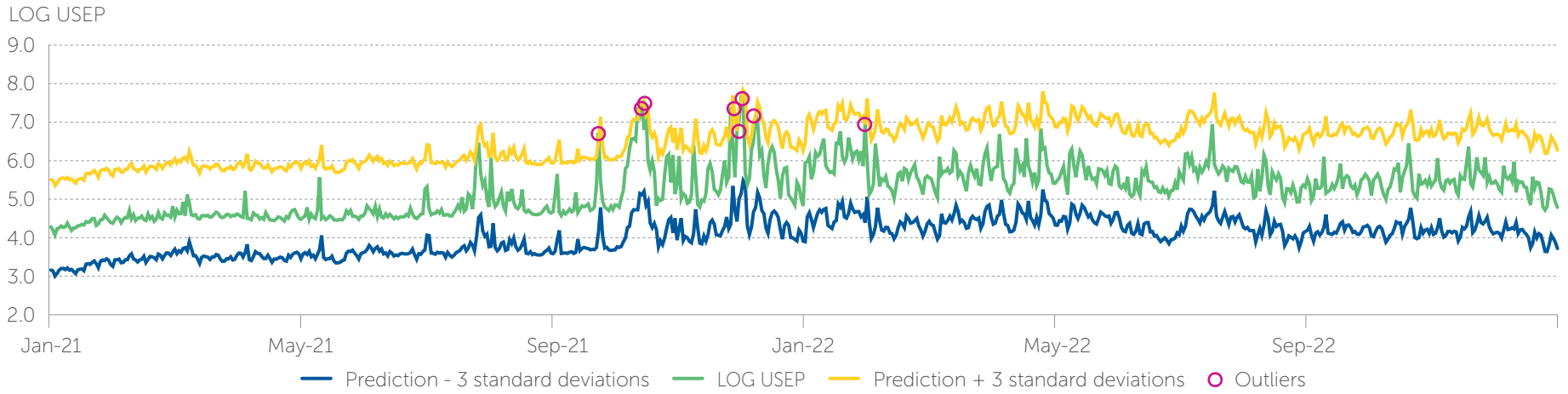


Chart 29 shows the actual daily average USEP, the upper and lower bands of the predicted daily average USEP, which are three standard deviations above and below the predicted USEP, and the outliers identified by the revised econometric model from January 2021 to December 2022, expressed on a logarithmic scale.

In 2021, seven outlier prices were recorded due to the extreme price volatility observed in Q4, and most of the outliers could not be explained by the parameters that explain the market conditions and dynamics in the model. 2021 was a year of price volatility in the wholesale market. This was particularly due to the unexpected gas supply disruption to Singapore, which is not an explanatory variable of MAU's econometric model. The surge in prices was mainly a reflection of elevated gas prices paid by generators to provide sufficient supply to the system to meet their contractual commitments.

Since then, the EMA has implemented emergency measures to stabilise the market and strengthen the market structure.

Identification of Outlier in 2022

The econometric model identified one price anomaly on 30 January 2022 where the USEP ($1,054.62/MWh) exceeded the upper band of the predicted USEP of $1,026.75/MWh. The high USEP could be explained by the relatively higher upstream gas curtailment levels observed on 30 January 2022, while the majority of January 2022 had no gas curtailment. The impact of upstream gas curtailment on the predicted USEP is not incorporated into the model. The upstream gas supply of some generation companies may have been affected by the gas curtailment, which could have contributed to the shift of their offer prices to more expensive tranches, including price tranches above $100/MWh.

This is evidenced by the daily average proportion of offers above $100/MWh on 30 January 2022 at 29.95%, 1.94 percentage point higher than the monthly average proportion of offers above $100/MWh recorded in January 2022.

The supply cushion and forecast demand on 30 January 2022 did not support the high USEP. On that date, the supply cushion (19.58%) was higher than the monthly average supply cushion of 17.78% recorded in January 2022 and the forecast demand (5,905 MW) was lower than the monthly average demand of 6,118 MW in January 2022.

Nevertheless, the USEP movements throughout 2022 were largely explainable by the variables used in the econometric model, as shown in Table 13, as there were fewer outliers this year as compared to 2021.


INVESTIGATIONS

SUMMARY OF INVESTIGATION ACTIVITIES

The Market Surveillance and Compliance Panel (MSCP) may initiate an investigation into any activity in the wholesale electricity market or into the conduct of a market participant, the Market Support Services Licensee, Energy Market Company or the Power System Operator that is brought to its attention by a referral or complaint from any source, or that the MSCP of its own volition determines as warranting an investigation.

Any investigation initiated by the MSCP is undertaken by the Market Assessment Unit at the direction of the MSCP, in accordance with the investigation process outlined in the Singapore Electricity Market Rules (Market Rules).

The MSCP may refuse to commence or may terminate an investigation when it is of the view that a complaint, referral or investigation is frivolous, vexatious, immaterial or unjustifiable, not directly related to the operation of the wholesale electricity market, or within the jurisdiction of another party.

Table 15 reflects the position regarding investigation and enforcement activities from the start of the market on 1 January 2003 to 31 December 2022, with the last column focusing on the period under review.

Determinations issued by the MSCP are published in accordance with the Market Rules.

Highlights of Enforcement Activities in 2022

- The MSCP reviewed 978 cases of offer variations after gate closure in 2022 and determined 416 cases to be in breach of the Market Rules. Of the 416 cases in breach, the MSCP took enforcement action on 29 cases and no further action on 387 cases. The remaining 562 cases of offer variations after gate closure were assessed by the MSCP to be not in breach.
- Regarding other cases, the MSCP completed five investigations in the year.
- In 2022, the MSCP issued 14 rule breach determinations on 29 cases of offer variations after gate closure and four other cases.
- The MSCP also received and conducted two hearings as part of its investigation process.
- There were no suspension or termination hearings conducted in relation to an event of default this year.
- A total of $1,021,000 in financial penalties[23] was imposed across seven rule breach determinations, with $750,000 being the highest financial penalty imposed on a party in breach. A non-compliance letter from the MSCP was issued for the remaining seven cases.
- The MSCP imposed an investigation cost of $15,000 for two rule breach determinations respectively and $2,000 for each of the remaining 12 rule breach determinations. A total of $54,000 in costs was imposed on the parties in breach in 2022.

TABLE 15: INVESTIGATION AND ENFORCEMENT STATISTICS

Rule Breaches	1 Jan 2003 to 31 Dec 2022	1 Jan to 31 Dec 2022
(A) Total number of offer variations after gate closure received	38,782	559
Total number of cases closed	38,664	978
• cases in which the MSCP determined a breach	228	29
• cases in which the MSCP determined no breach	18,359	562
• cases in which the MSCP took no further action	20,077	387
(B) Origin of cases (excluding offer variations after gate closure)	219	8
• self-reports	177	3
• referrals or complaints	35	5
• initiated by the MSCP	7	0
Total number of cases closed	215	5
• cases in which the MSCP determined a breach	144	4
• cases in which the MSCP determined no breach	14	0
• cases in which the MSCP took no further action	46	1
• cases in which the MSCP made a determination on an event of default	11	0
• suspension orders	6	0
• other orders	2	0
• termination orders	2	0
(C) Total number of MSCP hearings	19	2
• suspension hearings	10	0
• termination hearings	1	0
• investigation hearings	8	2
(D) Enforcement action		
• highest financial penalty imposed on a party in breach	$842,861	$750,000
• total financial penalties imposed on parties in breach	$2,356,861	$1,021,000
(E) Costs		
• highest award of costs imposed on a party in breach	$43,750	$15,000
• total costs imposed on parties in breach	$382,525	$54,000
Market Efficiency and Fairness	**1 Jan 2003 to 31 Dec 2022**	**1 Jan to 31 Dec 2022**
Total number of cases	8	0
• referrals or complaints	3	0
• initiated by the MSCP	5	0
Total number of cases closed	8	0

23 Financial penalties imposed by the MSCP are returned to the market as a component of the monthly energy uplift charge.


SECTIONS
50 & 51 OF THE
ELECTRICITY ACT

SECTIONS 50 AND 51 OF THE ELECTRICITY ACT

Competition-Related Provisions in the Electricity Act

The Energy Market Authority (EMA) is responsible for enforcing the electricity sector-specific anti-competitive agreements and abuse of dominance provisions contained in sections 50 and 51 of the Electricity Act, Chapter 89A.

Section 50 of the Electricity Act prohibits agreements, decisions, or concerted practices by persons, which have as their object or effect the prevention, restriction, or distortion of competition in any wholesale electricity market or the retail electricity market in Singapore. The prohibition applies to agreements, decisions, or concerted practices which:

- directly or indirectly fix purchase or selling prices or any other trading conditions of electricity in Singapore;
- limit or control generation of electricity, any wholesale electricity market, the retail electricity market, technical development, or investment in the electricity industry in Singapore;
- share markets or sources of supply of electricity in Singapore;
- apply dissimilar conditions to equivalent transactions with other trading parties, thereby placing them at a competitive disadvantage;
- make the conclusion of contracts subject to acceptance by the other parties of supplementary obligations which, by their nature or according to commercial usage, have no connection with the subject of such contracts; or
- provide for the acquisition, directly or indirectly, of shares in or the assets of an electricity licensee.

Section 51 of the Electricity Act prohibits any conduct on the part of one or more persons, which amounts to the abuse of a dominant position in any wholesale electricity market or the retail electricity market in Singapore, if it may affect trade within Singapore.

Conduct constitutes an abuse if it consists of:

- directly or indirectly imposing unfair purchase or selling prices or other unfair trading conditions of electricity in Singapore;
- limiting generation of electricity, any wholesale electricity market, the retail electricity market or technical development in the electricity industry in Singapore to the prejudice of consumers;
- applying dissimilar conditions to equivalent transactions with other trading parties, thereby placing them at a competitive disadvantage; or
- making the conclusion of contracts subject to acceptance by the other parties of supplementary obligations which, by their nature or according to commercial usage, have no connection with the subject of such contracts.

Reports to the EMA

The Market Rules provide for the MSCP Annual Report to include a summary of reports submitted to the EMA regarding any complaint received or any information uncovered that may indicate the possibility of anti-competitive agreements or the abuse of a dominant position, contrary to sections 50 or 51 of the Electricity Act.

The MAU, on behalf of the MSCP, also develops ad hoc reports on abnormal trends identified in the Uniform Singapore Energy Price (USEP), including a comprehensive analysis of the market drivers and other factors that may have contributed to the movements. While monitoring and carrying out investigative activities from January to December 2022, the MSCP observed that April and July 2022 experienced some of the highest periodic USEP levels in 2022.

Notably, the periodic USEP recorded close to the energy price ceiling for two periods on 17 July 2022 (Period 38 and Period 45) at $4,499.99/MWh. The sharp periodic USEP spikes in these two months resulted in an overall higher monthly USEP.

The MSCP submitted two reports to the EMA regarding the MSCP's observations on the USEP spikes for: (i) 1 April to 30 April 2022; and (ii) 1 to 31 July, 11 August and 12 August 2022.[24]

April and July 2022 recorded the second and third highest monthly USEP in 2022 respectively. The MSCP observed that the key reasons for the USEP spikes could have been attributed to:

- the overall increase in demand and decrease in supply;
- offer prices submitted by generation companies that shifted to higher price tranches;
- excess capacity not offered from generation facilities that were neither on planned maintenance nor on forced outage; and
- offer variations submitted just before gate closure.

Additional information the MSCP considered relevant to highlight for the EMA's attention includes any other offer behaviour that could have exacerbated the high price situation, and the net positions of the market participants that own both the generation and retail businesses.

While the MSCP noted that the offer submissions by the generation companies were driven by commercial interests and did not constitute any apparent breach of the Market Rules, the MSCP provided its recommendation to the EMA to look into the impact of the offer submissions and the facilities that did not offer into the system despite not on maintenance that may have exacerbated the high price situation during the price spikes.

24 While the highest monthly periodic USEP in the year was recorded in January at $483.09/MWh, the high prices were noted to have occurred in the context of global fuel shortage exacerbated by the unplanned curtailment of piped natural gas supply imported from Indonesia due to upstream gas supply issues.

Information Requirements to Assist the EMA

The Singapore Electricity Market Rules[25] (Market Rules) provide for the Market Assessment Unit (MAU), under the supervision and direction of the MSCP, to develop a set of information requirements to assist the EMA in fulfilling its obligations with respect to prohibiting anti-competitive agreements and abuse of a dominant position, under sections 50 and 51 of the Electricity Act.

The first set of information requirements was finalised in consultation with the EMA and published on 27 March 2003. As the market evolved, modifications to the information requirements were published on 18 August 2003, 28 January 2004, 3 April 2012, and 22 August 2016, with the latest modification made and published on 12 August 2020.

The MAU regularly provides data to the EMA according to the information requirements, as shown in the table below.

TABLE 16: INFORMATION REQUIREMENTS TO ASSIST THE AUTHORITY TO FULFIL ITS OBLIGATIONS WITH RESPECT TO COMPETITION AND ABUSE OF A DOMINANT POSITION UNDER SECTIONS 50 AND 51 OF THE ELECTRICITY ACT

No.	Description	Frequency of Collection	Means of Provision to EMA
1	Maximum capacity for primary reserve, contingency reserve, regulation, generation and load curtailment of each registered facility	Once and upon change	Electronic mail from EMC to EMA
2	Maximum combined generation capacity and reserve capacity of each registered facility	Once and upon change	Electronic mail from EMC to EMA
3	Maximum ramp-up and/or ramp-down rate of each registered facility	Once and upon change	Electronic mail from EMC to EMA
4	Offers and bids for energy, primary reserve, contingency reserve and regulation (prices and quantities) submitted by all market participants that are used in each dispatch run	Every two hours	Secure file transfer protocol (SFTP)* from EMC to EMA
5	All offer and bid variations and revisions to standing offers and bids for energy, primary reserve, contingency reserve and regulation	Every two hours	SFTP from EMC to EMA
6	Scheduled dispatch and load curtailment volumes by registered facility/market participants for all dispatch schedules, scenarios and re-runs	Every two hours	SFTP from EMC to EMA
7	Half-hourly market energy price (MEP) at all market network nodes (MNN) for all dispatch schedules, scenarios and re-runs	Every two hours	SFTP from EMC to EMA
8	Half-hourly prices and requirements for energy, primary reserve, contingency reserve, regulation and load curtailment for all dispatch schedules, scenarios and re-runs	Every two hours	SFTP from EMC to EMA
9	Metered injection and withdrawal quantities by registered facility/market participants, date and period	Daily	SFTP from EMC to EMA
10	Uplift charges by date and period	Daily	SFTP from EMC to EMA
11	Advisory notices reported by time, day and type	Daily	SFTP from EMC to EMA
12	Intertie quantities and prices by date and period	Daily	SFTP from EMC to EMA
13	Vesting contract reference prices by market participants, date and period	Monthly	SFTP from EMC to EMA

*SFTP is a direct link established between EMC and the EMA's databases to allow information to be transmitted directly from EMC to the EMA.

25 Section 4.3.10 of Chapter 3 of the Singapore Electricity Market Rules.

ASSESSMENT OF THE WHOLESALE ELECTRICITY MARKET

Under the Singapore Electricity Market Rules (Market Rules), the Market Surveillance and Compliance Panel (MSCP) is required to provide a general assessment of the state of competition and compliance within, and the efficiency of, the wholesale electricity market. The MSCP's assessment for 2022 is as follows:

Market Structure and Competition

Entry of New Market Participants
Five new market participants (MP) were registered in the National Electricity Market of Singapore (NEMS) in 2022:

Generation licensee
- 1 June 2022: Taser Power

Wholesale market trader
- 15 February 2022: Solarland Alpha Assets
- 11 March 2022: PSA Corporation
- 5 October 2022: Crystal Clear Environmental
- 13 October 2022: Terrenus Energy SL1X

New Facilities in the Market
In 2022, 11 new facilities joined the market. The first Electricity Import (Import) facility was registered in the NEMS on 13 June 2022. It is a 100 MW facility from Keppel Electric under the Lao PDR-Thailand-Malaysia-Singapore Power Integration Project which imports renewable hydropower from Lao PDR to Singapore via Thailand and Malaysia using existing interconnections.

Of the 11 facilities, three Intermittent Generation Sources (IGS) from Sembcorp Solar Singapore and Solarland Alpha Assets with a total registered capacity of 9.256 MW joined the market.

Additionally, four load facilities were registered in the NEMS this year. There were two Load Registered Facilities with a maximum capacity of 2.7 MW and 7.2 MW each from Diamond Electric, and a Load Registered Facility with a maximum capacity of 0.1 MW from Sunseap VPower. Singapore District Cooling registered a 4 MW capacity demand response facility.

Lastly, three Energy Storage Systems (ESS) registered in the NEMS. The ESS facilities belonged to PSA Corporation (a 1.7 MW ESS facility) and Sembcorp Cogen (two 100 MW ESS facilities).

Withdrawal of Market Participants and De-Registration of Facilities in the Market
In 2022, five MPs withdrew their participation in the NEMS.

- UGS Energy on 1 January 2022;
- Hyflux Energy on 31 March 2022;
- Tuaspring on 1 June 2022;
- Terrenus Energy on 5 November 2022; and
- Ohm Energy on 1 December 2022.

In view of the withdrawals of market participants, the 395.7 MW generation facility from Tuaspring was transferred to Taser Power, while the 4.65 MW IGS unit from Terrenus Energy was transferred to Terrenus Energy SL1X.

Market Price Behaviour

Electricity prices on the rise in 2022
The Uniform Singapore Energy Price (USEP) continued an upward trend in 2022. This was the second year that USEP had risen since 2020. The USEP increased 48.63% to an annual average of $291.81/MWh in 2022 from $196.33/MWh in 2021, while the Wholesale Electricity Price rose 49.74% to an annual average of $292.91/MWh in 2022, from $195.62/MWh in 2021.

Increases in the electricity market price were mainly driven by supply and demand conditions. Since the reopening of the Singapore economy on the back of the relaxation of the Covid-19 restrictions applied in 2021, forecasted electricity demand rose 1.97% from 6,179 MW to 6,300 MW this year. Supply, on the other hand, decreased 7.06% from 7,934 MW to 7,374 MW this year. The tight supply market was directly linked to the higher maintenance level observed this year – total outages rose 81.04% from 1,259.90 MW in 2021 to 2,280.86 MW this year and to excess capacity not offered to the market. As a result, supply cushion shrunk 7.76 percentage points from 22.19% to 14.44%.

The higher energy prices also coincided with higher fuel oil prices as they rose to an annual average of US$522.73/MT in 2022, from US$406.81/MT in 2021.

Industry and Market Efficiency of the Electricity Markets

Market Concentration
Market concentration measures the intensity of competition in the market by looking at the level of market share between market players. The less concentrated a market is, the more competitive it is.

The market share based on maximum capacity for the top three market players decreased from 60.20% to 59.33% in 2022. The dilution of the market concentration level could be attributed to the entry of new generation types, namely ESS and Import. In 2022, ESS and Import contributed 0.21% and 0.46% of the market share respectively based on maximum capacity.

In terms of metered energy quantity, the market share held by the three largest players in the NEMS rose 2.29 percentage points from 50.55% in 2021 to 52.84% this year. It is noteworthy that the composition of the top three market players changed in 2022. G5, G4, and G6 were the three market players dominating in 2021. However, in 2022, G2 replaced G6 to be the third largest market player in terms of metered energy quantity.

In 2022, the generation companies' market share in terms of metered energy quantity was, to a certain extent, influenced by the pre-emptive measures imposed by the Energy Market Authority (EMA) since October 2021 to secure Singapore's fuel and electricity supply in response to the global energy crunch and disruptions to the piped natural gas supply.

There are two schemes managed by the EMA, namely the Directed Supply Scheme where the EMA pre-emptively directs generation companies to generate in the event of a projected supply shortfall, and the Standby Capacity Scheme where the EMA procures standby generation capacity from participating generation licensees to increase generation supply if needed.

As a result, the generation company's market share fluctuated in 2022, depending on their participation in the schemes and the instances of activation by the EMA.

Productive Efficiency
The market share of the most efficient generation technology, the Combined Cycle Gas Turbine (CCGT) units, dropped in 2022, both in terms of maximum capacity and metered energy quantity. The market share based on maximum capacity decreased 1.29 percentage points from 89.38% to 88.09% in 2022. The decrease in market share of CCGT units was picked up by Other Facilities (OT) and the new generation types entering the market, such as ESS and Import. These two new generation types collectively contributed 0.67% of the market share in terms of maximum capacity.

The market share of CCGT units based on metered energy quantity decreased 0.94 percentage points from 98.10% to 97.16% in 2022. The drop in generation from CCGT units was due to more CCGT units undergoing planned maintenances this year. On the other hand, there was increased generation from Steam Turbines (ST) and OT, as well as generation from Import. The market share of ST and OT units rose 0.08 and 0.53 percentage point respectively in 2022, while Import contributed 0.34% of the total market generation this year.

Pricing Efficiency
Prices in the NEMS were observed to be generally consistent with the demand and supply conditions in the year. The USEP rose from $196.33/MWh to $291.81/MWh due to a tighter supply cushion caused by higher demand and lower supply. In particular, the demand rose 1.97% from 6,179 MW to 6,300 MW while the supply shrunk 7.06% from 7,934 MW to 7,374 MW. As a result, the supply cushion dropped 7.76 percentage points from 22.19% in 2021 to 14.44% in 2022, marking the lowest annual average supply cushion since the market started in 2003.

In 2022, 61.09% of the periodic supply cushion fell below 15% level, compared to 9.78% in 2021. Notwithstanding the higher instances of low supply cushion, the average periodic USEP when supply cushion was below the 15% level cleared at a significantly lower level at $348.60/MWh, compared to $621.02/MWh in 2021. This indicates that the market cleared at relatively lower price tranches under tighter supply conditions in 2022 compared to 2021, which occurred in the context of the EMA's measures that were introduced to stabilise the electricity market.

Actual or Potential Design or Other Flaws and Inefficiencies in the Market Rules and Overall Structure of the Wholesale Electricity Markets Identified by the MSCP

Issues submitted to the Rules Change Panel
During the MSCP's investigation work, the MSCP has identified flaws and inefficiencies in the Market Rules and the overall structure of the wholesale electricity markets. These issues were provided to the Rules Change Panel (RCP) for inclusion in its list of market issues for prioritisation.

The following proposals were submitted in 2022, which stem from the MSCP's monitoring and investigation work completed in 2021:

- Review of the timeline for suspension hearing;
- Review of provisions on suspension and termination orders; namely, to specify the applicant to lift/modify a suspension order made by the MSCP, and to clarify the process for the application for a termination order; and
- Holistic review of the Market Rules related to cessation of business, liquidation and insolvency.

In 2022, the MSCP also submitted its comments on the concept paper regarding the clarification of "failure to synchronise" in gate closure exemptions. The MSCP did not support the proposal to define the timestamp of a facility's "failure to synchronise" to be "the timestamp of the determination that the technical faults triggered will lead to the facility's inability to synchronise". EMC shared the same view as the MSCP and the recommendation not to support the proposal was unanimously supported by the RCP. As such, no rule change was required on the matter.

Arising from the MSCP's monitoring and investigation work conducted in 2022, the following proposals from the MSCP/MAU were considered in the 2023 RCP work plan exercise:

- Review of the definition of forced outages in gate closure exemptions; and
- Review of obligation to act within five minutes when an action is to be taken "promptly" or "immediately".

Looking Ahead

Enabling Demand Side Management Sandbox
On 3 November 2022, the EMA published a paper on enhancing the demand response (DR) and interruptible load (IL) programmes with a demand side management sandbox. A temporary sandbox scheme was launched on 1 January 2023 and will run to 31 December 2024 where:

1) participating Load Registered Facilities (LRF) providing DR will face lower compliance thresholds and lower penalty amounts; and

2) participating LRFs providing IL will be paid for scheduled reserve quantity for the first two instances of under-delivery upon activation.

Electricity Imports Plans to Boost Security and Diversify Supply
Singapore plans to import up to 4 gigawatts (GW) of electricity by 2035 to decarbonise the energy sector. In June 2022, Keppel Electric commenced the first renewable energy electricity import with 100 MW of hydropower renewable energy from Lao PDR.

The EMA is also working with PacificLight Power on a pilot to import 100 MW from a solar farm in Pulau Bulan, Indonesia. Under this scheme, electricity will be supplied via a new interconnector that directly connects a solar farm in Pulau Bulan to PacificLight Power's power station in Singapore. The pilot is expected to be commissioned by around 2024.

Singapore will also be importing 100 MW of electricity from Malaysia as part of a two-year trial, through a partnership between YTL PowerSeraya and TNB Genco, who are working closely with the EMA and Malaysia's Energy Commission to refine all technical settings and regulatory arrangements. The trial is expected to commence from the second half of 2023.

Singapore Launches National Hydrogen Strategy
Singapore launched the national hydrogen strategy to accelerate the transition to net zero emissions by 2050. As part of developing new energy supply sources, the introduction of hydrogen will complement and diversify Singapore's power mix alongside solar and Electricity Imports. A 600 MW hydrogen-powered advanced CCGT power plant is expected to be completed in the first half of 2026 and could supply up to half of Singapore's power needs by 2050.

Singapore Meets its 2025 Energy Storage Deployment Target Early
In November 2022, Sembcorp Cogen commissioned the largest battery storage project in Southeast Asia with a 200 MW battery energy storage system. This exceeded Singapore's deployment target of 200MWh of energy storage by 2025, which was set by the EMA to achieve its aim to deploy at least 2 GW peak of installed capacity by 2030.

Ensuring compliance is important in the operation of a competitive and reliable electricity market. Market participants (MP) that breach the rules may be subject to sanctions if the Market Surveillance and Compliance Panel (MSCP) considers it appropriate.

The assessment as to the state of compliance within the wholesale electricity market is set out below.

Offer Variations After Gate Closure

Currently, the Singapore Wholesale Electricity Market has a gate closure period of 65 minutes. Any offer variation data that is submitted within 65 minutes of the beginning of a dispatch period will be reported by Energy Market Company (EMC) to the MSCP for investigation.

However, not all offer variations after gate closure are prohibited under the Market Rules. Specified circumstances are provided for in the Market Rules as exceptions that allow offer variations to be submitted after gate closure.

Chart 30 compares the number of offer variations after gate closure submitted by MPs in 2022 with those of previous years.

The number of offer variations after gate closure in 2022 dropped 30.04% to 559 cases. The surge in offer variations after gate closure cases in 2021 was observed in the later months of the year, which coincided with the occurrences of unplanned piped natural gas curtailment (the shortage of gas required generation companies to conduct a fuel changeover from gas to diesel oil) and the volatile electricity spot price situation. This statistic dropped from 799 cases in 2021 to 599 cases in 2022 following the introduction of the Energy Market Authority's (EMA) measures to stabilise the power system and market under the Directed Supply Scheme (DSS) and Standby Capacity Scheme (SCS). The drop in the number of cases from last year could be due to less fuel changeover requirements, the availability of the EMA's standby gas facility, and generation companies becoming more familiar with how the mechanisms are applied.

CHART 30: OFFER VARIATIONS MADE AFTER GATE CLOSURE

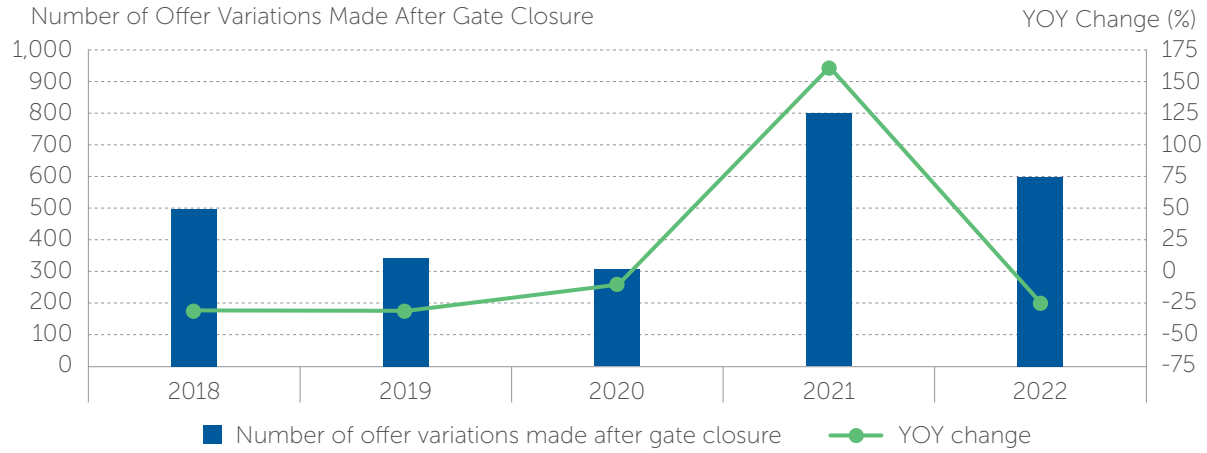


TABLE 17: OFFER VARIATIONS MADE AFTER GATE CLOSURE

Year	Number of Offer Variations Made After Gate Closure	YOY Change (%)
2018	497	-30.88
2019	342	-31.19
2020	306	-10.53
2021	799	161.11
2022	559	-30.04

Nonetheless, the number of offer variations after gate closure cases in 2022 remained higher than the years before the upstream gas network issues occurred in 2021, with offer variations necessitated to be submitted after gate closure as per the EMA/Power System Operator's (PSO) directions. Given that these offer variations were as directed by the EMA and the PSO under the SCS and DSS schemes respectively, they were deemed by the EMA to be treated as non-breaches of the Market Rules.

Must-Schedule Requirement for Electricity Imports

One of the obligations of Electricity Imports include having to ensure that its energy schedule for every hour is no less than the minimum scheduled quantity set by the EMA, save for prescribed circumstances, namely whether the Import Registered Facility or any part of the interties is on outage and if it had been ordered, directed or instructed by the PSO to be scheduled at a different level. Any breach of the foregoing requirement will be reported to the MSCP for investigation.

The MSCP did not receive any breaches of the must-schedule requirement in 2022.

Rule Breach Determinations Issued

For the period 1 January to 31 December 2022, the MSCP issued 14 determinations regarding rule breaches and dismissed one appeal received for a refund of financial penalty under the Automatic Financial Penalty Scheme (AFPS).

The determinations issued by the MSCP are a result of the Market Assessment Unit's (MAU) investigation and examination for the MSCP's deliberation. The MSCP's determinations are listed by breach type under the following subheadings:

Failure to Comply with Gate Closure Rules
Ten MSCP rule breach determinations were issued in 2022 in respect of eight market participants for 29 offer variations after gate closure:

- Singapore's Refining Company's offer variations after gate closure on 1 September 2021;
- Keppel Merlimau Cogen's offer variations after gate closure on 27 September 2021;
- Tuas Power Generation's offer variations after gate closure on 26 November 2021;
- Tuas Power Generation's offer variations after gate closure on 16 February 2022;
- Shell Eastern Petroleum's offer variations after gate closure on 4 March 2022;
- YTL PowerSeraya's offer variations after gate closure on 17 April 2022;
- Senoko Waste-to-Energy's offer variations after gate closure on 26 April 2022;
- YTL PowerSeraya's offer variations after gate closure on 14 July 2022
- Pacificlight Power's offer variations after gate closure on 27 July 2022; and
- Taser Power's offer variations after gate closure on 8 August 2022.

Failure to comply with PSO's directions
YTL PowerSeraya was served two rule breach determinations from the MSCP in 2022 for its failure to comply with the PSO's directions issued under the DSS.

- YTL PowerSeraya's JUR GT1 failure to comply with the PSO's directions on 7 July 2022; and
- YTL PowerSeraya's SER CCP2 failure to comply with the PSO's directions on 7 July 2022.

Failure to Comply with the Market Operation Responsibilities under the Market Rules
EMC was served two rule breach determinations from the MSCP in 2022.

- Energy Market Company's late validation of offer on 15 July 2022; and
- Energy Market Company's failure to comply with Market Operations Timetable on 12 July 2022.

Appeal for Refund of Financial Penalties Under the Automatic Financial Penalty Scheme
The MSCP received one appeal for refund of financial penalty under the AFPS in 2022.

- TuasOne's appeal for refund of financial penalty for non-compliance event on 26 January 2022.

There were no suspension or termination orders issued by the MSCP in 2022, compared to five such related orders in 2021.

Similar to past years, most of the rule breach determinations issued in 2022 related to cases of failure to comply with gate closure rules. Of the ten investigations on failure to comply with gate closure rules, the MSCP determined five instances to have been the result of human error on the part of the market participants (MP). The MSCP also issued warnings to these MPs to always observe their obligations under the Market Rules.

2022 also saw the second highest financial penalty imposed on an MP since the market started in 2003. The MSCP determined that YTL PowerSeraya was in breach for SER CCP2's failure to comply with the PSO's directions on 7 July 2022. Considering the need to send a strong signal that compliance with the PSO's dispatch directions is vital in the national interest and the necessity for specific deterrence where an MP has been guilty of repeated breaches of the Market Rules, the MSCP imposed a financial penalty of $750,000 on YTL PowerSeraya.

During the course of the MSCP investigations, the MSCP observed that some of the generation assets in the market are aging as they approach the end of their economic life. Some generators have indicated to the MSCP that operating these plants poses several challenges due to reduced efficiency and higher maintenance requirements. As a consequence, such plants may not be able to perform to expectations when directed by the PSO to generate and support with the provision of system security.

The MSCP has highlighted that there is an obligation on generators to operate and maintain its facilities and equipment in a manner consistent with the reliable operation of the power system, to support the overall objective of maintaining a stable and secure energy supply to consumers. The MSCP stressed that compliance with the PSO's dispatch directions is vital in the national interest and MPs cannot and should not take their obligations lightly in this respect.

MSCP's Role to Safeguard the Financial Integrity of the Wholesale Electricity Market

The MSCP receives information from EMC when a notice of default[26] is issued. Such a notice is issued by EMC to a defaulting MP in accordance with section 7.3.3 of Chapter 3 of the Market Rules, and provides detailed information to the MSCP when an MP has been unable to remit to the EMC settlement clearing account by the end of the business day following its payment due date.

Under the circumstances[27] when a default notice has been issued, the MAU and the MSCP remain vigilant for further information and confirmation by EMC about the default event's remedy. If a default is not remedied, EMC takes the steps required by the Market Rules, which include issuing a request for a suspension hearing to the MSCP. Subsequently, the MAU works closely with EMC to make sure that all relevant information about the defaulting MP's financial situation is provided in order to prepare the facts that will form the basis for the MSCP's decision, along with the evidence presented to the Panel on the day of the hearing. All decisions and orders issued by the MSCP after a suspension hearing are made in accordance with the Market Rules, to minimise the market financial risk exposure and ultimately to safeguard the financial integrity of the NEMS.

In 2022, EMC issued a total of four default notices to MPs, in comparison to 19 notices of default issued in 2021. The defaults were all successfully remedied in accordance with the Market Rules and there was no request received by the MSCP to conduct a suspension or termination hearing. The MSCP and MAU continue to be vigilant and committed in their monitoring and actions in accordance with the Market Rules to safeguard the financial integrity of the wholesale electricity market.

Automatic Financial Penalty Scheme

The Automatic Financial Penalty Scheme (AFPS) for Generation Registered Facilities that deviate from their dispatch schedule came into effect on 17 November 2015.

In 2022, 12 generation companies were issued automatic financial penalties amounting to a total sum of $931,878.54. The market also saw a total of $96,253.91 penalty imposed on two Load Registered Facilities under the AFPS.

As observed in Table 18, there was an annual 84.19% increase in the amount of financial penalties imposed under the AFPS from $558,186.77 in 2021 to $1,028,132.45 in 2022. There were 95 periods penalised under the AFPS in 2022 as compared to 54 periods a year ago.

TABLE 18: FINANCIAL PENALTIES IMPOSED UNDER THE AFPS ($)

Year	Financial Penalties Imposed Under the AFPS
2015 (from 17 Nov)	82,262.00
2016	544,846.25
2017	530,283.45
2018	401,146.29
2019	338,636.02
2020	288,401.00
2021	558,186.77
2022	1,028,132.45

The MSCP received one appeal from TuasOne for a refund of financial penalty for a non-compliance event on 26 January 2022. The appeal was dismissed by the MSCP on the grounds that there was no excuse for TuasOne's non-compliance with the dispatch instructions from the PSO pursuant to section 9.6.3 of Chapter 5 of the Market Rules. The MSCP imposed costs of $4,500 on TuasOne.

26 A default notice is a notice issued by EMC to a market participant pursuant to section 9.2.1.1 of Chapter 2 or section 7.3.3.1 of Chapter 3 of the Market Rules, and has, where applicable, the extended meaning ascribed thereto in section 9.1.5 of Chapter 2 of the Market Rules.

27 Circumstances when an event of default is declared are specified in section 7.3.1 of Chapter 3 of the Market Rules.

CONCLUSION

The Market Surveillance and Compliance Panel (MSCP) is generally satisfied with the state of compliance in the National Electricity Market of Singapore (NEMS) in 2022. The MSCP issued 14 rule breach determinations over the year. Additionally, there was a decrease in the number of cases related to offer variations submitted after gate closure, with the number dropping from 799 in 2021 to 559 in 2022.

In 2022, Singapore's Wholesale Electricity Price recorded its highest level observed since the inception of the NEMS in 2003 in a context of high demand coupled with tight supply conditions, higher levels of maintenance, and excess Combined Cycle Gas Turbine (CCGT) capacity not offered to the market because of issues related to gas availability during the second half of the year. The year began with high volatility in the wholesale electricity prices due to continued gas supply disruptions at the upstream gas production facility in Indonesia.[28] From February 2022, the situation worsened with the surge in oil prices and gas production outages, exacerbated by the geopolitical tensions between Russia and Ukraine. Singapore's dependence on imported natural gas for electricity generation was particularly affected by shortages in gas supply. Nonetheless, measures taken by the Energy Market Authority (EMA) to strengthen the Singapore Wholesale Electricity Market (SWEM) and to safeguard energy security helped to stabilise the wholesale electricity prices for the remainder of the year.

The EMA established a Standby Liquefied Natural Gas Facility (SLF), for generation companies to utilise in the event of any disruptions to their piped natural gas supplies. In situations when there is an anticipated supply shortfall in the SWEM to meet the required demand, the EMA can proactively instruct generation companies to produce electricity using gas from the SLF, under the Directed Supply Scheme (DSS). In addition to the DSS, the EMA introduced the Standby Capacity Scheme (SCS). The MSCP has discussed and acknowledged the EMA's requirements regarding the enforcement of the Market Rules and recognises the Authority's efforts to prioritise and further enhance energy security, system stability, and reliability of supply in Singapore's electricity market.

Against this backdrop, the MSCP assessed multiple cases of non-compliance and received referrals from the Power System Operator (PSO) regarding rule breaches related to dispatch instructions. To address these concerns, the Market Assessment Unit (MAU) worked in coordination with the PSO to analyse relevant information about breaches of the Market Rules potentially affecting system security and reliability of supply, as well as leading to any price distortion that could have had an impact on market conditions or the financial integrity of the market.

The MSCP took enforcement action in accordance with the provisions of the Market Rules to deter the recurrence of breaches, ensure compliance by market participants with the Market Rules, and safeguard the financial integrity of the wholesale electricity market in Singapore.

The market share of the CCGT units, the most efficient generation technology in Singapore in terms of both energy output and maximum capacity, continued to be the most dominant in 2022. Nonetheless, the level of concentration in electricity generation has diminished as the combined market share of the three largest generation companies has gradually decreased in the last five years in terms of maximum capacity, signalling an improvement in market competitiveness. This was observed in the context of a moderately concentrated market.

Five new market participants (MP) joined the NEMS in 2022. The NEMS's total registered capacity also increased with 11 new facilities entering the market, bringing the total registered facilities in the NEMS to 125 units with a collective maximum generation capacity of 12,540.07 megawatts (MW) and maximum load curtailment capacity of 53.20 MW. The total number of Intermittent Generation Sources (IGS) facilities increased by three to 55 units this year, with a collective maximum generation capacity of 373.16 MW, an increase of 81.15 MW a year ago. 2022 also welcomed the entry of three new battery facilities with an additional 203.50 MW of generation capacity, bringing the total number of battery facilities in the NEMS to four.

Technological advancements in electricity generation have led to new facilities being registered in the market. This has necessitated the expansion of the Catalogue of Data to ensure that the MSCP has the ability to detect compliance issues with a higher level of accuracy and completeness of data collection, ensure more effective monitoring and surveillance of MPs, and enable the Panel

28 Ministry of Trade and Industry parliamentary reply, 1 November 2021, "Oral reply to PQs on Energy-related matters".

to promptly respond to any compliance issues. With this objective, the MSCP updated the Catalogue of Data to accommodate the inclusion of new types of electricity generation technology registered in the market, including Electricity Import Facilities, Energy Storage Systems, and Intermittent Generation Facilities.

The MSCP released quarterly reports that outlined the effectiveness of the measures implemented by the market authority in stabilising prices (such as the Standby Liquefied Natural Gas Facility, the Directed Supply Scheme, and the Standby Capacity Scheme) further mitigating supply shortages and reducing market distortions in the face of market conditions that put upward pressure on the wholesale electricity prices. In addition to the quarterly reports, the MSCP also published its determinations issued in cases of non-compliance, the enforcement actions taken, and the views of the Panel on the severity of the breaches. The aim is to promote transparency and accountability. This is to provide confidence to MPs that the Market Rules are enforced to ensure fairness to all.

During 2022, the MSCP provided its views regarding proposed rule modifications to review the existing processes established under the Market Rules, such as clarification of failure to synchronise in gate closure exemptions. The MSCP, in the course of its investigations, has also identified legal inconsistencies and inefficiencies in the Market Rules and the overall structure of the wholesale electricity markets. Suggestions were submitted to the Rules Change Panel for inclusion in the list of market issues for prioritisation.

The MSCP is committed to continuously promoting the growth and progress of the NEMS. To achieve this, the Panel will maintain its critical role in enforcing compliance with the Market Rules and expanding its market monitoring and surveillance capabilities. As the market evolves, the MSCP will ensure that it adapts its approach to remain effective in upholding the integrity and efficiency of the market.

The MSCP commends the work of the Market Assessment Unit (MAU) and is highly satisfied with the support that has been provided to the Panel. The knowledge and technical expertise of the MAU in undertaking the NEMS monitoring and surveillance activities, the investigation of alleged breaches of the Market Rules, and the advisory functions to the MSCP on enforcement actions to be taken against MPs who are found to be non-compliant are acknowledged with thanks. The Panel recognises that their contributions have been instrumental in promoting compliance with the Market Rules and enhancing market monitoring and surveillance. The MSCP recognises the importance of maintaining effective oversight of the market to ensure stability, as it consolidates its path towards a more efficient and effective operation.

Finally, the MSCP acknowledges with appreciation the service of Mr Er Lee Keh Sai over many years since he first joined the Panel in 2003. Er Lee's professional expertise and experience have been invaluable in the deliberations of the Panel, especially when technical matters are concerned. The MSCP also acknowledges the significant contributions of Mr T P B Menon as Chairman from 2016 to 2021. It is noted with gratitude that Mr Menon has agreed to remain as a member of the MSCP until 2024.

Professor Walter Woon
Chairman
Market Surveillance and Compliance Panel

USER GUIDE

Data

- Due to rounding, numbers presented throughout this report may not add up precisely to the totals indicated, and percentages may not precisely reflect the absolute figures for the same reason.
- All real-time and forecast prices and settlement data are provided by Energy Market Company.
- LNG Vesting Prices are provided by SP Services as the Market Support Services Licensee (MSSL) on the Open Electricity Market website every quarter, based on a list of long run marginal cost parameters of a Combined Cycle Gas Turbine (CCGT) unit from the Energy Market Authority, including capital cost, non-fuel operating cost, carbon price and fuel oil price.
- Data for forecast demand and outages is compiled from reports prepared by the Power System Operator (PSO), including advisory notices.
- Throughout this report, demand figures are based on the forecast demand supplied by the PSO, except where metered energy quantities are indicated.
- Metered energy quantities are supplied by SP Services. All metered data used in this report is final data, derived after any settlement re-runs.
- CCGT units refer to all generating units clustered under the CCGT/cogen/trigen umbrella.
- Due to technical errors, certain values may have been revised from references made to previous years' Annual Reports.

Peak, Shoulder, and Off-Peak Periods

The definitions of the peak, shoulder, and off-peak periods referred to in the MSCP Annual Report are shown in Table 19.

TABLE 19: DEFINITION OF PEAK, SHOULDER AND OFF-PEAK PERIODS*

	Sunday/Public Holiday	Weekday	Saturday
Peak	–	Periods 18–41	–
Shoulder	Periods 22–46	Periods 15–17 Periods 42–48	Periods 18–47
Off-peak	Periods 1–21 Periods 47–48	Periods 1–14	Periods 1–17 Period 48

* Source: MSSL

Supply Indices

- Capacity ratio indicates the utilisation of a generation facility as a ratio of its scheduled output of energy, reserves and regulation to its maximum generation capacity.
- Supply cushion is the ratio between (a) the difference between supply and demand and (b) supply. Supply cushion measures supply adequacy, the level of capacity which was offered but not scheduled and could be called up if necessary. The supply is the sum of offers submitted by generation companies. Demand refers to the forecast demand used by the Power System Operator (PSO) to determine the real-time dispatch schedule.
- The maximum generation capacity for each generation company is the maximum generation capacity in the standing capability data.
- Under the Singapore Electricity Market Rules (Market Rules) and the System Operation Manual (SOM), outages of Generation Registered Facilities are defined as follows:
  a) planned outage is defined in the SOM to "include both the Annual Outage Plan for overhaul, retrofitting or inspection and the Short-term Outage Plan for urgent repair or maintenance"; and
  b) forced outage is defined in the Market Rules as "an unanticipated intentional or automatic removal from service of equipment or the temporary de-rating of, restriction of use or reduction in performance of equipment".

There may be slight differences in the outage figures in the MSCP Annual Report and the NEMS Market Report due to differing methodologies.

Periods

Each day is divided into 48 half-hour periods. Period 1 is from 0000 to 0029 and Period 48 is from 2330 to 2359.

Names of Business Entities

The MSCP Annual Report refers to business entities by their commonly used names instead of the full names registered with the Accounting and Corporate Regulatory Authority. Specifically, information related to company ownership is not reflected, e.g. exempt private company, private/public company limited by shares, public company limited by guarantee, etc.

NOTICE AND DISCLAIMER

This publication is meant only for general information and nothing in it should be construed as advice. Whilst the Market Surveillance and Compliance Panel (MSCP) has taken reasonable care in the preparation of this publication, the MSCP does not warrant its suitability for any purpose. You should always consult your professional advisors before relying on this publication to make any decision.

If you have any specific queries about this publication, you may write to mau@emcsg.com.

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